# MAGICC/SCENGEN: User-friendly software for GCM inter-comparisons, climate scenario development and uncertainty assessment.

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# THE MAGICC/SCENGEN SOFTWARE : PURPOSES

- Climate scenario development for non-expert users and integrated assessment modelling
- ‘Hands on’ education for climate change issues
- Access to climate model and observed climate data bases

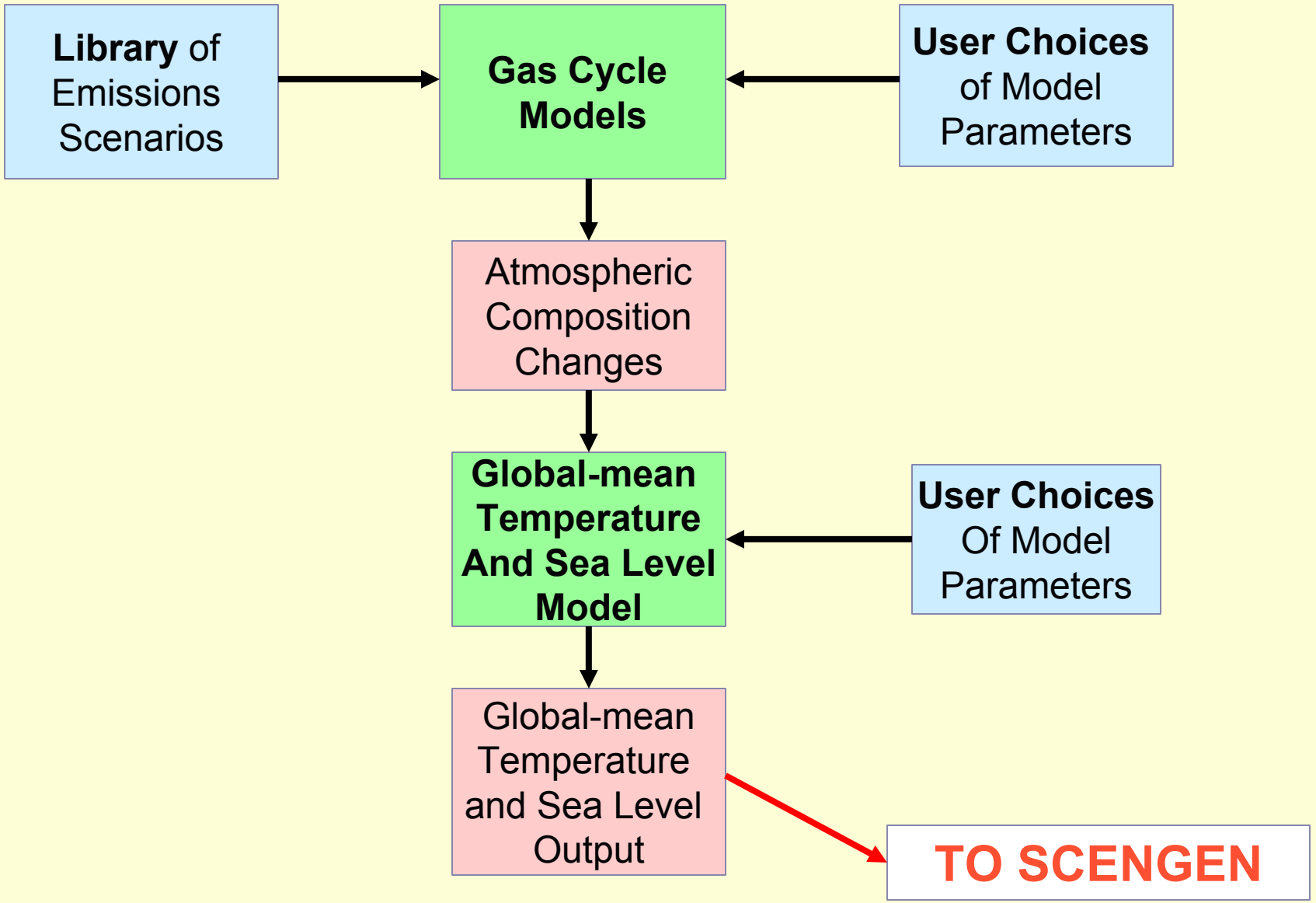
# THE MAGICC/SCENGEN SOFTWARE

**Global-mean component** : **M**odel for the **A**ssessment of **G**reenhouse-gas **I**nduced **C**limate **C**hange (MAGICC)

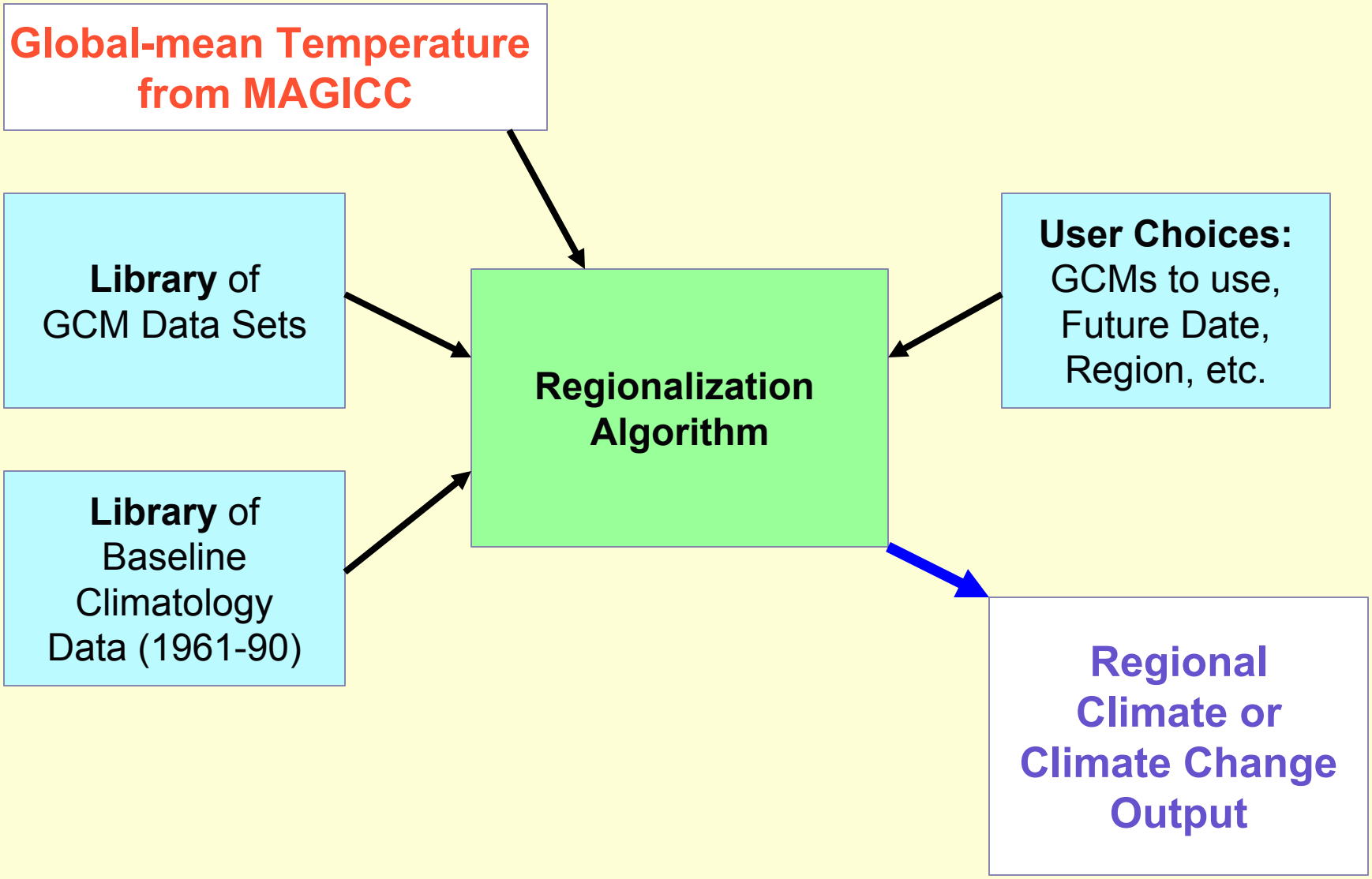
**Regional climate component** : **SCEN**ario **GEN**erator (SCENGEN)

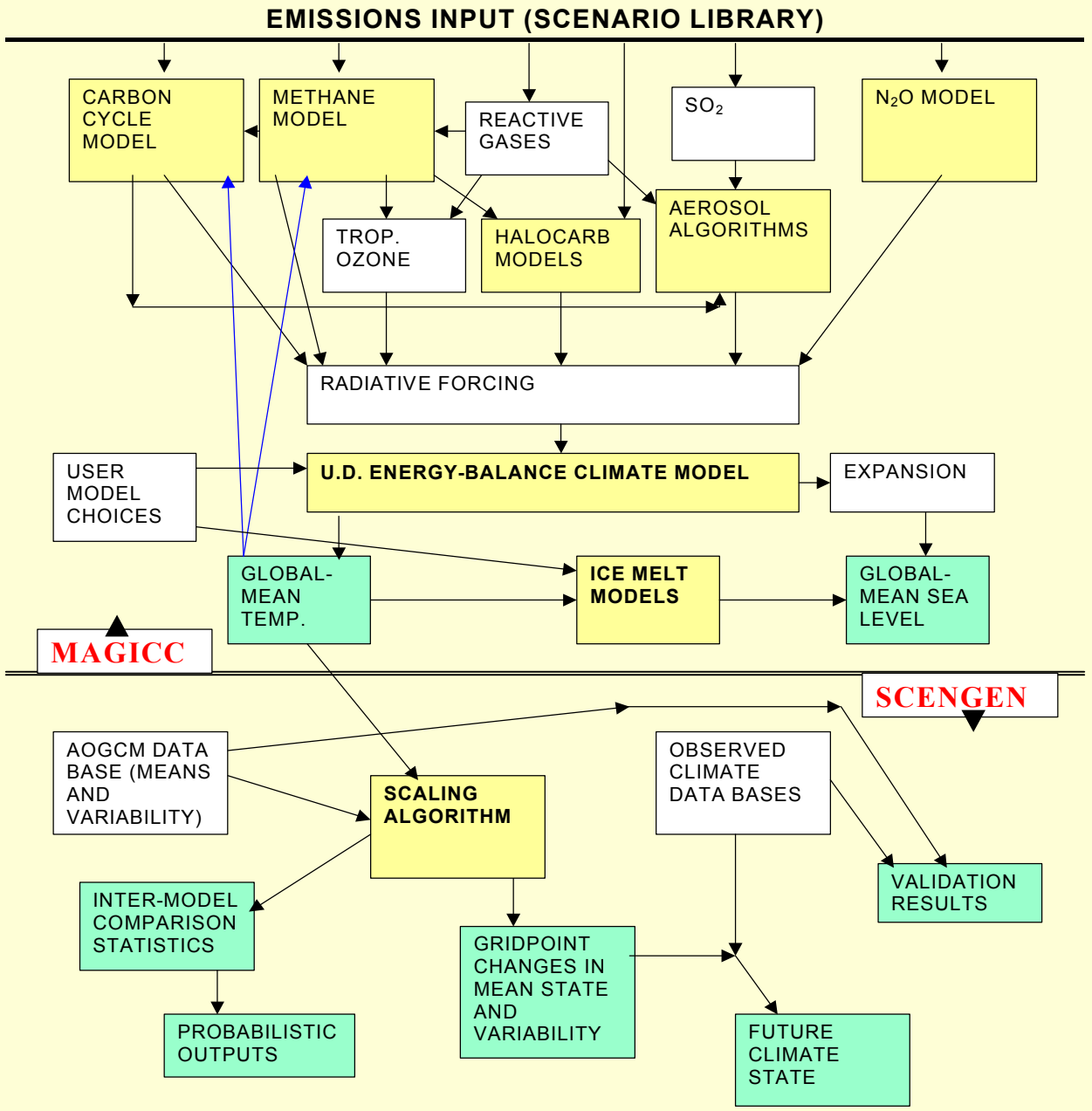
[Developed by Tom Wigley, GUI by Seth McGinnis; funded by EPA through Stratus Consulting]

# THE MAGICC/SCENGEN SOFTWARE : MAGICC



# THE MAGICC/SCENGEN SOFTWARE : SCENGEN

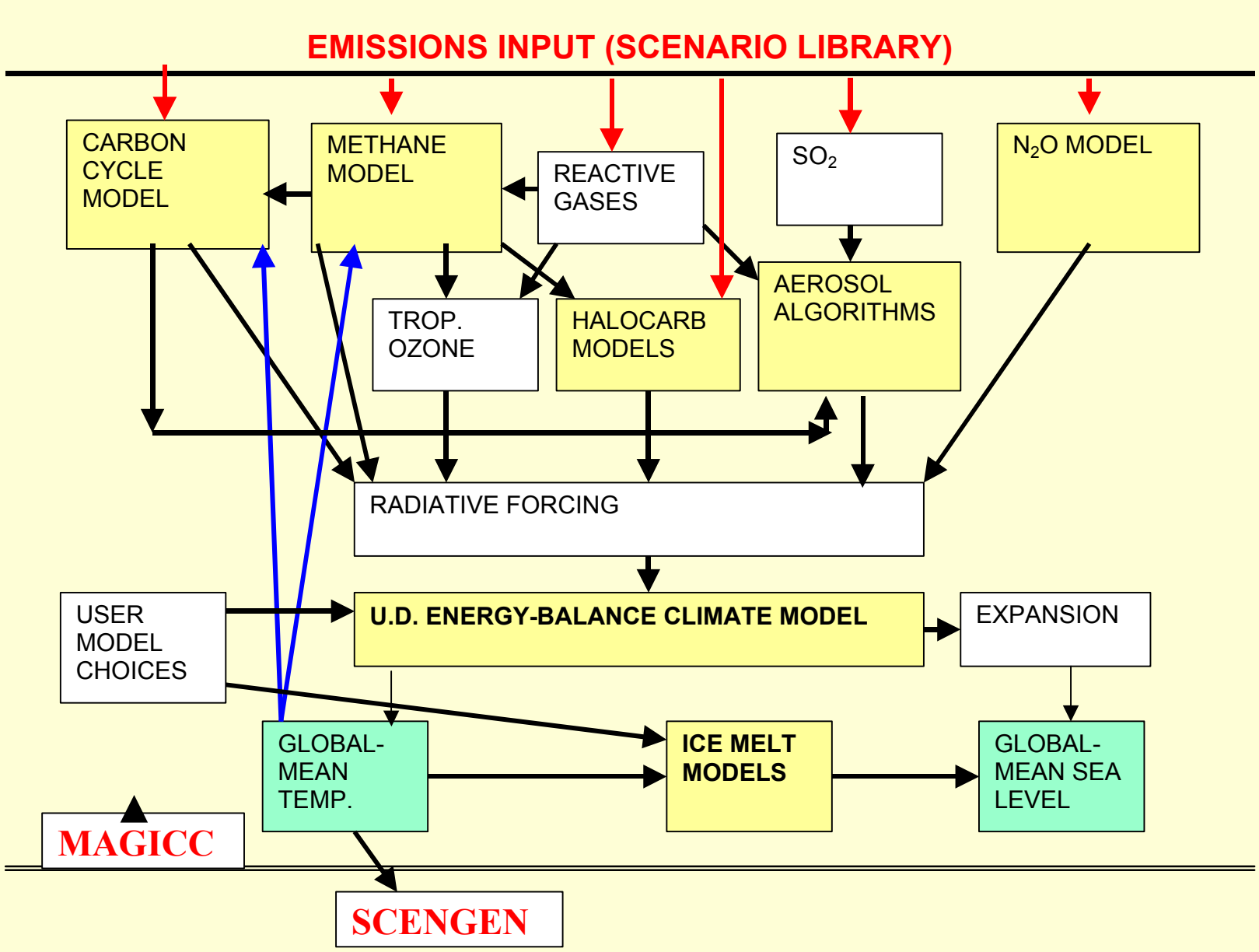



EMISSIONS INPUT (SCENARIO LIBRARY)
CARBON CYCLE MODEL
METHANE MODEL
REACTIVE GASES
$SO_2$
$N_2O$ MODEL
TROP. OZONE
HALOCARB MODELS
AEROSOL ALGORITHMS
RADIATIVE FORCING
USER MODEL CHOICES
U.D. ENERGY-BALANCE CLIMATE MODEL
EXPANSION
GLOBAL-MEAN TEMP.
ICE MELT MODELS
GLOBAL-MEAN SEA LEVEL
MAGICC
SCENGEN
AOGCM DATA BASE (MEANS AND VARIABILITY)
SCALING ALGORITHM
OBSERVED CLIMATE DATA BASES
VALIDATION RESULTS
INTER-MODEL COMPARISON STATISTICS
GRIDPOINT CHANGES IN MEAN STATE AND VARIABILITY
PROBABILISTIC OUTPUTS
FUTURE CLIMATE STATE

# PRIMARY INPUT : EMISSIONS SCENARIOS

## GASES CONSIDERED:

$CO_2$
$CH_4$
$N_2O$
$SO_2$
Reactive gases (CO, $NO_x$, VOCs)
Halocarbons (CFCs, HCFCs, HFCs, PFCs, $SF_6$)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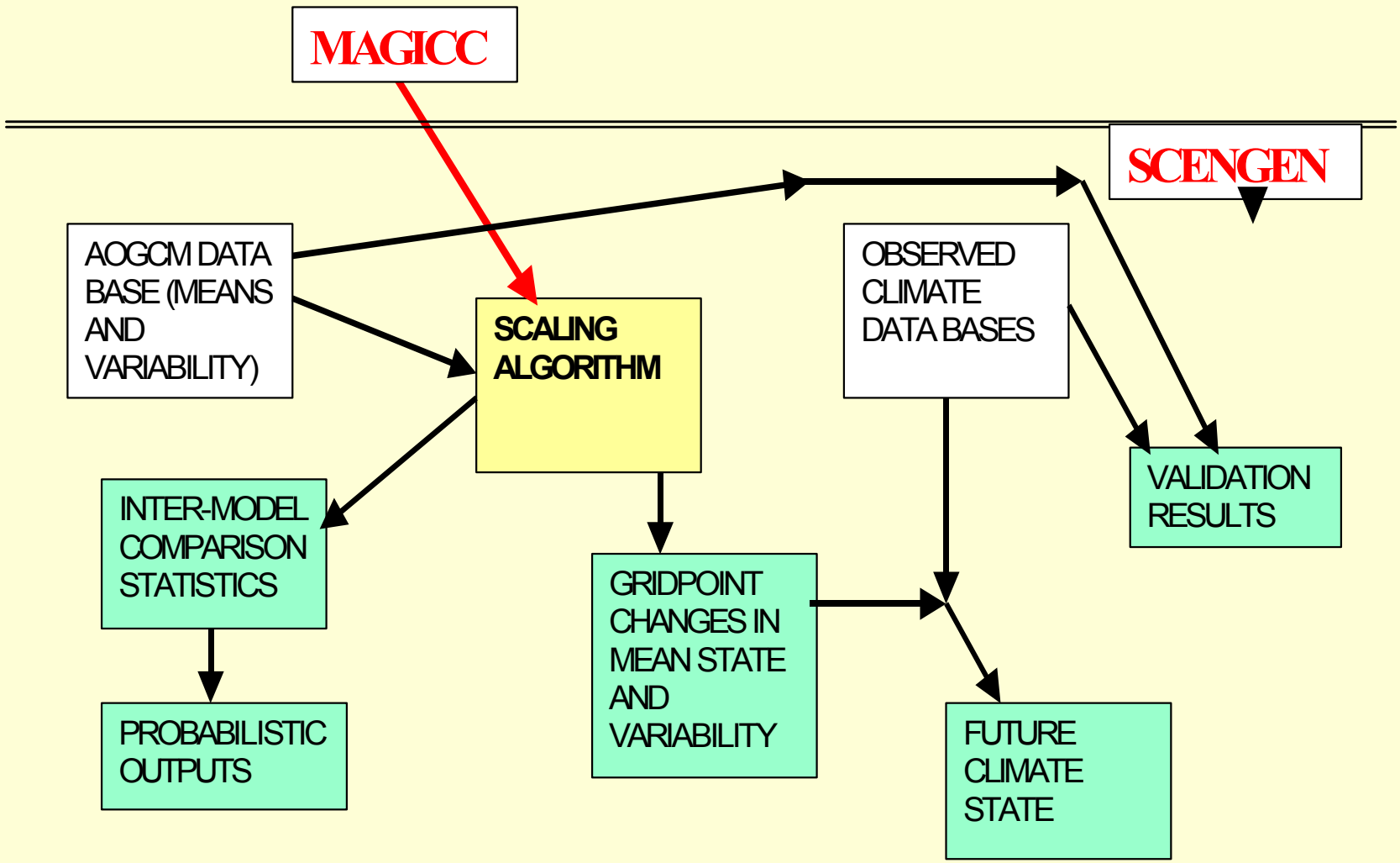
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# SIMPLE PATTERN SCALING

$$\Delta Y(x,t) = \Delta T(t)\, Y(x)$$

where

$\Delta Y(x,t)$ is the pattern of change at time t of some variable Y (winter precipitation, July maximum temperature, etc.),

$\Delta T(t)$ is the global-mean temperature change at time t,

$Y(x)$ is the normalized pattern of change for variable Y (i.e., the change per 1°C global-mean warming).

# GENERAL PATTERN SCALING

$$\Delta Y(x,t) = \Sigma \Delta T_i(t)\, Y_i(x)$$

where

$\Delta Y(x,t)$ is the pattern of change at time t for variable Y,

$\Delta T_i(t)$ is the global-mean temperature change at time t due to factor ‘i’,

$Y_i(x)$ is the normalized pattern of change for variable Y due to factor ‘i’.

# SOURCES OF UNCERTAINTY—REGIONAL SCALE

(1) Uncertainties in global-mean temperature (due to uncertainties in emissions, climate sensitivity, etc.)

(2) Uncertainties in normalized patterns of change: i.e., patterns of change per unit global-mean warming (quantifiable by comparing results from different models)

## MAGICC OUTPUTS:

Gas concentrations,
Radiative forcing breakdown,
Global-mean temperature and sea level.

## SCENGEN OUTPUTS:

Baseline climate data,
Model validation results,
Changes in  mean climate,
Changes in variability,
Signal-to noise ratios,
Probabilities of increase.

17 MODELS : **VARIABLE = TEMP : SEASON = ANN**

**VALIDATION: COMPARING MODEL BASELINE WITH OBSERVED DATA**

AREA SPECIFIED BY MASK. MASKFILE = MASK.A : MASKNAME = GLOBE

| MODEL | CORREL | RMSE degC | MEAN DIFF degC | NUM PTS |
|---|---|---|---|---|
| BMRCTR | .985 | 3.042 | -1.631 | 2592 |
| CCC1TR | .983 | 2.642 | -.264 | 2592 |
| CCSRTR | .982 | 2.785 | -.578 | 2592 |
| CERFTR | .985 | 3.855 | -2.760 | 2592 |
| **CSI2TR** | **.988** | **2.464** | **.198** | **2592** |
| CSM_TR | .990 | 2.409 | 1.287 | 2592 |
| ECH3TR | .987 | 2.531 | -.971 | 2592 |
| ECH4TR | **.995** | 1.679 | -.644 | 2592 |
| GFDLTR | .987 | 3.522 | 2.376 | 2592 |
| GISSTR | .985 | 2.556 | -.394 | 2592 |
| HAD2TR | **.995** | **1.578** | .435 | 2592 |
| HAD3TR | .994 | 1.779 | .462 | 2592 |
| IAP_TR | .982 | 3.706 | .138 | 2592 |
| LMD_TR | **.959** | **4.437** | **.027** | 2448 |
| MRI_TR | .986 | 3.072 | -1.515 | 2592 |
| PCM_TR | .991 | 2.627 | 1.720 | 2592 |
| W&M_TR | .978 | 4.547 | **-3.249** | 2592 |
| **MODBAR** | **.995** | **1.526** | **-.317** | **2592** |

17 MODELS : **VARIABLE = PRECIP : SEASON = ANN**

**VALIDATION: COMPARING MODEL BASELINE WITH OBSERVED DATA**

AREA SPECIFIED BY MASK. MASKFILE = MASK.A : MASKNAME = GLOBE

| MODEL | CORREL | RMSE mm/day | MEAN DIFF mm/day | NUM PTS |
|---|---|---|---|---|
| BMRCTR | .721 | 1.643 | -.295 | 2592 |
| CCC1TR | .715 | 1.529 | -.119 | 2592 |
| CCSRTR | .744 | 1.382 | .073 | 2592 |
| CERFTR | .802 | 1.277 | -.364 | 2592 |
| **CSI2TR** | **.864** | **1.037** | **-.104** | **2592** |
| CSM_TR | .785 | 1.411 | -.370 | 2592 |
| ECH3TR | .826 | 1.185 | -.061 | 2592 |
| ECH4TR | **.908** | **.936** | -.145 | 2592 |
| GFDLTR | .736 | 1.400 | **.051** | 2592 |
| GISSTR | .729 | 1.535 | -.424 | 2592 |
| HAD2TR | .886 | 1.097 | -.378 | 2592 |
| HAD3TR | .870 | 1.168 | -.238 | 2592 |
| IAP_TR | **.660** | 1.679 | .489 | 2592 |
| LMD_TR | .686 | 1.623 | -.207 | 2448 |
| MRI_TR | .697 | 1.562 | -.247 | 2592 |
| PCM_TR | .670 | 1.688 | -.357 | 2592 |
| W&M_TR | .678 | **1.992** | **-1.066** | 2592 |
| **MODBAR** | **.910** | **.904** | **-.221** | **2592** |

17 MODELS : **VARIABLE = TEMP** -- LINEAR SCALING : **SEASON = ANN**

*** DEFINITION 2 RESULTS ONLY ***

**MODELS : BMRCTR98 : CCC1TR99 : CCSRTR96 : CERFTR98 : CSI2TR96 CSM_TR98 : ECH3TR95 : ECH4TR98 : GFDLTR90 : GISSTR95 : HAD2TR95 : HAD3TR00 : IAP_TR97 : LMD_TR98 : MRI_TR96 : PCM_TR00 : W&M_TR95**

AREA SPECIFIED BY MASK. MASKFILE = MASK.A : MASKNAME = GLOBE

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**INTER-MODEL CORRELN RESULTS FOR NORMALIZED CHANGES IN MEAN STATE**

INTER-MODEL CORRELATION MATRIX : OVERALL RBAR = .5783

| | | | |
|---|---|---|---|
| MAX CORREL, RANK = 1 : | (11,12) : | **.901** : | ( HAD2D2, HAD3D2) |
| MAX CORREL, RANK = 2 : | ( 6,16) : | .876 : | ( CSM_D2, PCM_D2) |
| MAX CORREL, RANK = 3 : | ( 2,15) : | .857 : | ( CCC1D2, MRI_D2) |
| MAX CORREL, RANK = 4 : | ( 3,15) : | .850 : | ( CCSRD2, MRI_D2) |
| MAX CORREL, RANK = 5 : | ( 3,11) : | .846 : | ( CCSRD2, HAD2D2) |
| MAX CORREL, RANK = 6 : | ( 2, 3) : | .842 : | ( CCC1D2, CCSRD2) |
| MAX CORREL, RANK = 7 : | (11,15) : | .839 : | ( HAD2D2, MRI_D2) |
| MAX CORREL, RANK = 8 : | ( 9,11) : | .833 : | ( GFDLD2, HAD2D2) |
| | | | |
| MIN CORREL, RANK = 1 : | (13,15) : | **-.197** : | ( IAP_D2, MRI_D2) |
| MIN CORREL, RANK = 2 : | ( 8,13) : | -.179 : | ( ECH4D2, IAP_D2) |
| MIN CORREL, RANK = 3 : | (10,13) : | -.165 : | ( GISSD2, IAP_D2) |
| MIN CORREL, RANK = 4 : | ( 9,13) : | -.116 : | ( GFDLD2, IAP_D2) |
| MIN CORREL, RANK = 5 : | (11,13) : | -.098 : | ( HAD2D2, IAP_D2) |
| MIN CORREL, RANK = 6 : | ( 6,13) : | -.082 : | ( CSM_D2, IAP_D2) |
| MIN CORREL, RANK = 7 : | ( 3,13) : | -.046 : | ( CCSRD2, IAP_D2) |
| MIN CORREL, RANK = 8 : | (12,13) : | -.021 : | ( HAD3D2, IAP_D2) |

# CORRELATION MATRIX FOR NORMALIZED ANNUAL TEMPERATURE CHANGE

| | BMRCD2 | CCC1D2 | CCSRD2 | CERFD2 | CSI2D2 | CSM_D2 | ECH3D2 | ECH4D2 | GFDLD2 | GISSD2 | HAD2D2 | HAD3D2 | IAP_D2 | LMD_D2 | MRI_D2 | PCM_D2 | W&M_D2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMRCD2 | 100 | 81 | 76 | 83 | 65 | 67 | 76 | 60 | 79 | 65 | 80 | 77 | 9 | 51 | 78 | 60 | 60 |
| CCC1D2 | 81 | 100 | 84 | 79 | 62 | 60 | 73 | 65 | 80 | 73 | 77 | 75 | 1 | 42 | 86 | 50 | 61 |
| CCSRD2 | 76 | 84 | 100 | 74 | 65 | 62 | 74 | 60 | 81 | 78 | 85 | 80 | -5 | 57 | 85 | 53 | 72 |
| CERFD2 | 83 | 79 | 74 | 100 | 67 | 66 | 70 | 65 | 74 | 63 | 79 | 78 | 4 | 50 | 77 | 58 | 55 |
| CSI2D2 | 65 | 62 | 65 | 67 | 100 | 76 | 57 | 62 | 74 | 38 | 78 | 81 | 2 | 54 | 67 | 79 | 60 |
| CSM_D2 | 67 | 60 | 62 | 66 | 76 | 100 | 45 | 48 | 70 | 53 | 73 | 73 | -8 | 50 | 70 | 88 | 60 |
| ECH3D2 | 76 | 73 | 74 | 70 | 57 | 45 | 100 | 67 | 74 | 54 | 69 | 71 | 21 | 53 | 59 | 41 | 51 |
| ECH4D2 | 60 | 65 | 60 | 65 | 62 | 48 | 67 | 100 | 74 | 39 | 70 | 68 | -18 | 38 | 62 | 35 | 39 |
| GFDLD2 | 79 | 80 | 81 | 74 | 74 | 70 | 74 | 74 | 100 | 62 | 83 | 83 | -12 | 56 | 83 | 60 | 61 |
| GISSD2 | 65 | 73 | 78 | 63 | 38 | 53 | 54 | 39 | 62 | 100 | 61 | 55 | -16 | 31 | 74 | 33 | 58 |
| HAD2D2 | 80 | 77 | 85 | 79 | 78 | 73 | 69 | 70 | 83 | 61 | 100 | 90 | -10 | 68 | 84 | 65 | 72 |
| HAD3D2 | 77 | 75 | 80 | 78 | 81 | 73 | 71 | 68 | 83 | 55 | 90 | 100 | -2 | 68 | 82 | 72 | 73 |
| IAP_D2 | 9 | 1 | -5 | 4 | 2 | -8 | 21 | -18 | -12 | -16 | -10 | -2 | 100 | -2 | -20 | 9 | 0 |
| LMD_D2 | 51 | 42 | 57 | 50 | 54 | 50 | 53 | 38 | 56 | 31 | 68 | 68 | -2 | 100 | 54 | 55 | 57 |
| MRI_D2 | 78 | 86 | 85 | 77 | 67 | 70 | 59 | 62 | 83 | 74 | 84 | 82 | -20 | 54 | 100 | 62 | 73 |
| PCM_D2 | 60 | 50 | 53 | 58 | 79 | 88 | 41 | 35 | 60 | 33 | 65 | 72 | 9 | 55 | 62 | 100 | 58 |
| W&M_D2 | 60 | 61 | 72 | 55 | 60 | 60 | 51 | 39 | 61 | 58 | 72 | 73 | 0 | 57 | 73 | 58 | 100 |
| MEANMOD | 89 | 89 | 91 | 87 | 80 | 79 | 79 | 73 | 90 | 74 | 93 | 92 | -2 | 67 | 91 | 72 | 75 |
| | BMRCD2 | CCC1D2 | CCSRD2 | CERFD2 | CSI2D2 | CSM_D2 | ECH3D2 | ECH4D2 | GFDLD2 | GISSD2 | HAD2D2 | HAD3D2 | IAP_D2 | LMD_D2 | MRI_D2 | PCM_D2 | W&M_D2 |
| AVE-COR | 69 | 67 | 69 | 67 | 64 | 62 | 62 | 55 | 70 | 54 | 72 | 72 | 3 | 52 | 69 | 58 | 59 |

17 MODELS : **VARIABLE = PRECIP** -- LINEAR SCALING : **SEASON = ANN**

*** DEFINITION 2 RESULTS ONLY ***

**MODELS : BMRCTR98 : CCC1TR99 : CCSRTR96 : CERFTR98 : CSI2TR96 CSM_TR98 : ECH3TR95 : ECH4TR98 : GFDLTR90 : GISSTR95 : HAD2TR95 : HAD3TR00 : IAP_TR97 : LMD_TR98 : MRI_TR96 : PCM_TR00 : W&M_TR95**

AREA SPECIFIED BY MASK. MASKFILE = MASK.A : MASKNAME = GLOBE

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**INTER-MODEL CORRELN RESULTS FOR NORMALIZED CHANGES IN MEAN STATE**

INTER-MODEL CORRELATION MATRIX : OVERALL RBAR = .2478

| | | | |
|---|---|---|---|
| MAX CORREL, RANK = 1 | ( 5,12) | **.569** | ( CSI2D2, HAD3D2) |
| MAX CORREL, RANK = 2 | ( 5,15) | .488 | ( CSI2D2, MRI_D2) |
| MAX CORREL, RANK = 3 | ( 5,17) | .477 | ( CSI2D2, W&M_D2) |
| MAX CORREL, RANK = 4 | ( 1, 6) | .463 | ( BMRCD2, CSM_D2) |
| MAX CORREL, RANK = 5 | ( 5,14) | .462 | ( CSI2D2, LMD_D2) |
| MAX CORREL, RANK = 6 | ( 8,12) | .453 | ( ECH4D2, HAD3D2) |
| MAX CORREL, RANK = 7 | ( 1, 7) | .427 | ( BMRCD2, ECH3D2) |
| MAX CORREL, RANK = 8 | ( 6,16) | .422 | ( CSM_D2, PCM_D2) |
| | | | |
| MIN CORREL, RANK = 1 | ( 7,14) | **-.140** | ( ECH3D2, LMD_D2) |
| MIN CORREL, RANK = 2 | ( 5, 7) | -.088 | ( CSI2D2, ECH3D2) |
| MIN CORREL, RANK = 3 | ( 7,12) | .015 | ( ECH3D2, HAD3D2) |
| MIN CORREL, RANK = 4 | ( 1,10) | .033 | ( BMRCD2, GISSD2) |
| MIN CORREL, RANK = 5 | ( 7,17) | .040 | ( ECH3D2, W&M_D2) |
| MIN CORREL, RANK = 6 | ( 7,13) | .041 | ( ECH3D2, IAP_D2) |
| MIN CORREL, RANK = 7 | ( 7, 8) | .045 | ( ECH3D2, ECH4D2) |
| MIN CORREL, RANK = 8 | ( 2,13) | .056 | ( CCC1D2, IAP_D2) |

# CORRELATION MATRIX FOR NORMALIZED ANNUAL PRECIPITATION CHANGE

| | BMRCD2 | CCC1D2 | CCSRD2 | CERFD2 | CSI2D2 | CSM_D2 | ECH3D2 | ECH4D2 | GFDLD2 | GISSD2 | HAD2D2 | HAD3D2 | IAP_D2 | LMD_D2 | MRI_D2 | PCM_D2 | W&M_D2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BMRCD2 | 100 | 25 | 33 | 29 | 17 | 46 | 43 | 11 | 29 | 3 | 12 | 16 | 18 | 16 | 17 | 12 | 19 |
| CCC1D2 | 25 | 100 | 19 | 33 | 24 | 27 | 11 | 16 | 22 | 15 | 18 | 16 | 6 | 10 | 22 | 13 | 19 |
| CCSRD2 | 33 | 19 | 100 | 36 | 32 | 37 | 31 | 32 | 42 | 34 | 40 | 23 | 25 | 34 | 39 | 20 | 31 |
| CERFD2 | 29 | 33 | 36 | 100 | 34 | 23 | 17 | 36 | 33 | 16 | 32 | 32 | 25 | 26 | 38 | 18 | 17 |
| CSI2D2 | 17 | 24 | 32 | 34 | 100 | 28 | -9 | 40 | 40 | 29 | 30 | 57 | 36 | 46 | 49 | 13 | 48 |
| CSM_D2 | 46 | 27 | 37 | 23 | 28 | 100 | 37 | 26 | 29 | 19 | 23 | 23 | 15 | 19 | 31 | 42 | 21 |
| ECH3D2 | 43 | 11 | 31 | 17 | -9 | 37 | 100 | 5 | 26 | 19 | 9 | 1 | 4 | -14 | 18 | 30 | 4 |
| ECH4D2 | 11 | 16 | 32 | 36 | 40 | 26 | 5 | 100 | 38 | 17 | 41 | 45 | 19 | 29 | 39 | 17 | 22 |
| GFDLD2 | 29 | 22 | 42 | 33 | 40 | 29 | 26 | 38 | 100 | 25 | 34 | 39 | 30 | 26 | 34 | 20 | 29 |
| GISSD2 | 3 | 15 | 34 | 16 | 29 | 19 | 19 | 17 | 25 | 100 | 22 | 18 | 10 | 8 | 38 | 17 | 22 |
| HAD2D2 | 12 | 18 | 40 | 32 | 30 | 23 | 9 | 41 | 34 | 22 | 100 | 23 | 11 | 29 | 31 | 29 | 31 |
| HAD3D2 | 16 | 16 | 23 | 32 | 57 | 23 | 1 | 45 | 39 | 18 | 23 | 100 | 32 | 28 | 36 | 19 | 31 |
| IAP_D2 | 18 | 6 | 25 | 25 | 36 | 15 | 4 | 19 | 30 | 10 | 11 | 32 | 100 | 18 | 23 | 6 | 30 |
| LMD_D2 | 16 | 10 | 34 | 26 | 46 | 19 | -14 | 29 | 26 | 8 | 29 | 28 | 18 | 100 | 30 | 8 | 30 |
| MRI_D2 | 17 | 22 | 39 | 38 | 49 | 31 | 18 | 39 | 34 | 38 | 31 | 36 | 23 | 30 | 100 | 26 | 36 |
| PCM_D2 | 12 | 13 | 20 | 18 | 13 | 42 | 30 | 17 | 20 | 17 | 29 | 19 | 6 | 8 | 26 | 100 | 16 |
| W&M_D2 | 19 | 19 | 31 | 17 | 48 | 21 | 4 | 22 | 29 | 22 | 31 | 31 | 30 | 30 | 36 | 16 | 100 |
| MEANMOD | 50 | 38 | 65 | 55 | 60 | 62 | 48 | 57 | 60 | 54 | 53 | 55 | 41 | 41 | 65 | 49 | 48 |
| | BMRCD2 | CCC1D2 | CCSRD2 | CERFD2 | CSI2D2 | CSM_D2 | ECH3D2 | ECH4D2 | GFDLD2 | GISSD2 | HAD2D2 | HAD3D2 | IAP_D2 | LMD_D2 | MRI_D2 | PCM_D2 | W&M_D2 |
| AVE-COR | 26 | 23 | 36 | 32 | 36 | 32 | 19 | 31 | 35 | 24 | 30 | 32 | 24 | 26 | 36 | 24 | 30 |

17 MODELS : **VARIABLE = TEMP** -- LINEAR SCALING : **SEASON = ANN**

*** DEFINITION 2 RESULTS ONLY ***

**MODELS : BMRCTR98 : CCC1TR99 : CCSRTR96 : CERFTR98 : CSI2TR9**
**CSM_TR98 : ECH3TR95 : ECH4TR98 : GFDLTR90 : GISSTR95 : HAD2TR95 : HAD3TR00 :**
**IAP_TR97 : LMD_TR98 : MRI_TR96 : PCM_TR00 : W&M_TR95**

AREA SPECIFIED BY MASK. MASKFILE = MASK.A : MASKNAME = GLOBE

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**UNWEIGHTED PATTERN CORRELS BETWEEN NORMALIZED S.D. CHANGE FIELDS**

INTER-MODEL CORRELATION MATRIX : OVERALL RBAR = .0616

| | | | |
|---|---|---|---|
| MAX CORREL, RANK = 1 | (10,11) | **.444** | ( GISSD2, HAD2D2) |
| MAX CORREL, RANK = 2 | ( 5,10) | .343 | ( CSI2D2, GISSD2) |
| MAX CORREL, RANK = 3 | ( 2,10) | .343 | ( CCC1D2, GISSD2) |
| MAX CORREL, RANK = 4 | ( 2,11) | .319 | ( CCC1D2, HAD2D2) |
| MAX CORREL, RANK = 5 | (10,15) | .308 | ( GISSD2, MRI_D2) |
| MAX CORREL, RANK = 6 | (11,16) | .272 | ( HAD2D2, PCM_D2) |
| MAX CORREL, RANK = 7 | ( 6,10) | .264 | ( CSM_D2, GISSD2) |
| MAX CORREL, RANK = 8 | ( 2, 5) | .260 | ( CCC1D2, CSI2D2) |

| | | | |
|---|---|---|---|
| MIN CORREL, RANK = 1 | (10,17) | **-.178** | ( GISSD2, W&M_D2) |
| MIN CORREL, RANK = 2 | (12,13) | -.175 | ( HAD3D2, IAP_D2) |
| MIN CORREL, RANK = 3 | (11,17) | -.175 | ( HAD2D2, W&M_D2) |
| MIN CORREL, RANK = 4 | ( 2,17) | -.161 | ( CCC1D2, W&M_D2) |
| MIN CORREL, RANK = 5 | ( 4,13) | -.149 | ( CERFD2, IAP_D2) |
| MIN CORREL, RANK = 6 | ( 3,16) | -.149 | ( CCSRD2, PCM_D2) |
| MIN CORREL, RANK = 7 | (13,16) | -.143 | ( IAP_D2, PCM_D2) |
| MIN CORREL, RANK = 8 | (12,17) | -.141 | ( HAD3D2, W&M_D2) |

17 MODELS : **VARIABLE = PRECIP** -- LINEAR SCALING : **SEASON = ANN**

*** DEFINITION 2 RESULTS ONLY ***

**MODELS : BMRCTR98 : CCC1TR99 : CCSRTR96 : CERFTR98 : CSI2TR96 CSM_TR98 : ECH3TR95 : ECH4TR98 : GFDLTR90 : GISSTR95 : HAD2TR95 : HAD3TR00 : IAP_TR97 : LMD_TR98 : MRI_TR96 : PCM_TR00 : W&M_TR95**

AREA SPECIFIED BY MASK. MASKFILE = MASK.A : MASKNAME = GLOBE

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**UNWEIGHTED PATTERN CORRELS BETWEEN NORMALIZED S.D. CHANGE FIELDS**

INTER-MODEL CORRELATION MATRIX : OVERALL RBAR = .0326

| | | | |
|---|---|---|---|
| MAX CORREL, RANK = 1 | ( 1, 7) | **.253** | ( BMRCD2, ECH3D2) |
| MAX CORREL, RANK = 2 | ( 7,16) | .231 | ( ECH3D2, PCM_D2) |
| MAX CORREL, RANK = 3 | ( 8,15) | .163 | ( ECH4D2, MRI_D2) |
| MAX CORREL, RANK = 4 | ( 5,12) | .161 | ( CSI2D2, HAD3D2) |
| MAX CORREL, RANK = 5 | ( 1, 6) | .157 | ( BMRCD2, CSM_D2) |
| MAX CORREL, RANK = 6 | ( 8,12) | .153 | ( ECH4D2, HAD3D2) |
| MAX CORREL, RANK = 7 | ( 5, 8) | .151 | ( CSI2D2, ECH4D2) |
| MAX CORREL, RANK = 8 | ( 6,14) | .138 | ( CSM_D2, LMD_D2) |
| | | | |
| MIN CORREL, RANK = 1 | ( 2,11) | **-.094** | ( CCC1D2, HAD2D2) |
| MIN CORREL, RANK = 2 | ( 6,12) | -.087 | ( CSM_D2, HAD3D2) |
| MIN CORREL, RANK = 3 | (16,17) | -.071 | ( PCM_D2, W&M_D2) |
| MIN CORREL, RANK = 4 | ( 5,11) | -.057 | ( CSI2D2, HAD2D2) |
| MIN CORREL, RANK = 5 | (11,13) | -.056 | ( HAD2D2, IAP_D2) |
| MIN CORREL, RANK = 6 | ( 4, 9) | -.051 | ( CERFD2, GFDLD2) |
| MIN CORREL, RANK = 7 | (12,14) | -.050 | ( HAD3D2, LMD_D2) |
| MIN CORREL, RANK = 8 | ( 7,11) | -.048 | ( ECH3D2, HAD2D2) |

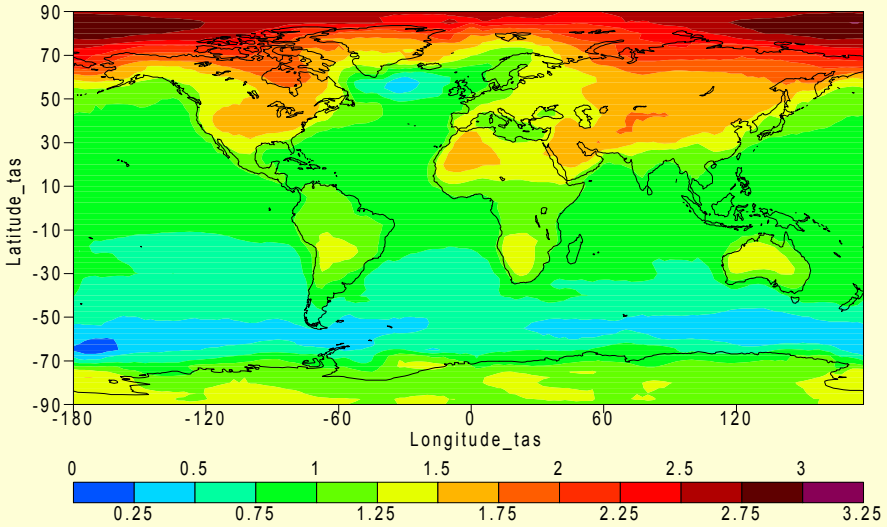
# RESULTS FOR PATTERNS OF CLIMATE CHANGE

(per 1°C global-mean warming)

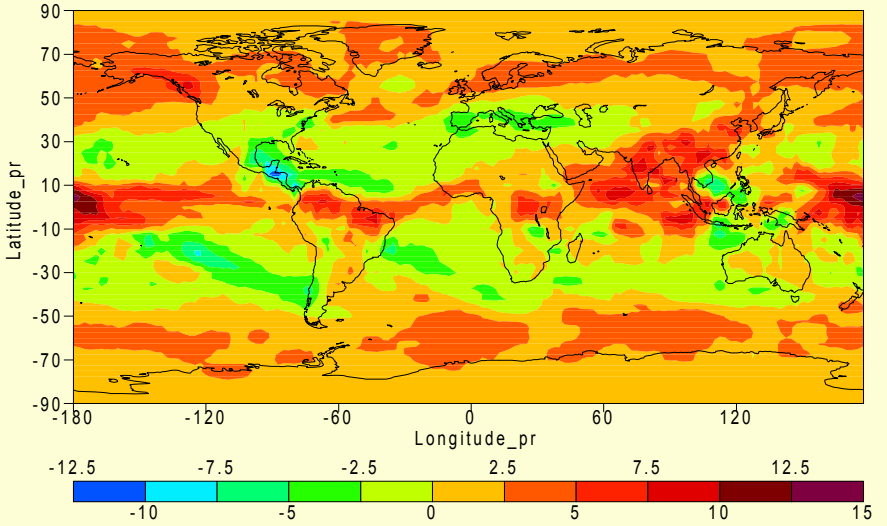
[Average results for 16 coupled ocean-atmosphere climate models]

# Normalized annual-mean temperature and precipitation changes in CMIP2 Greenhouse Warming Experiments (1%/year $CO_2$ increase)

**Normalized temperature change**

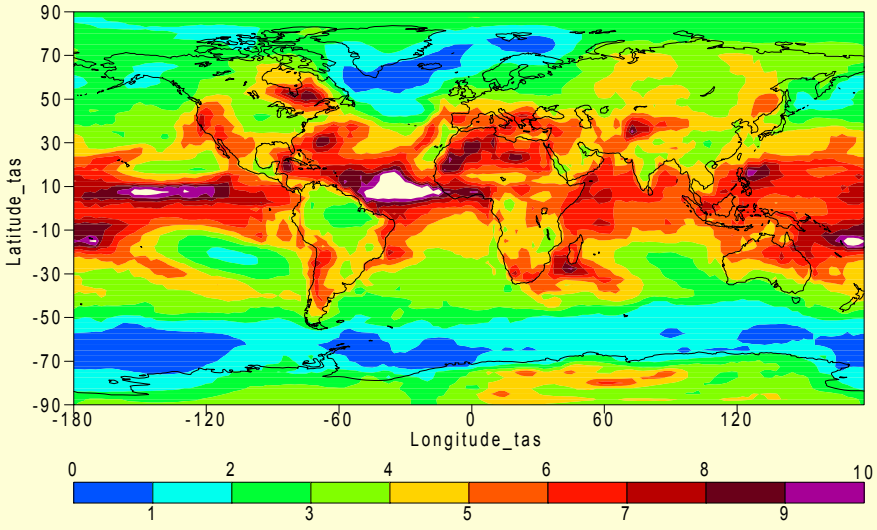



**Normalized precipitation change**

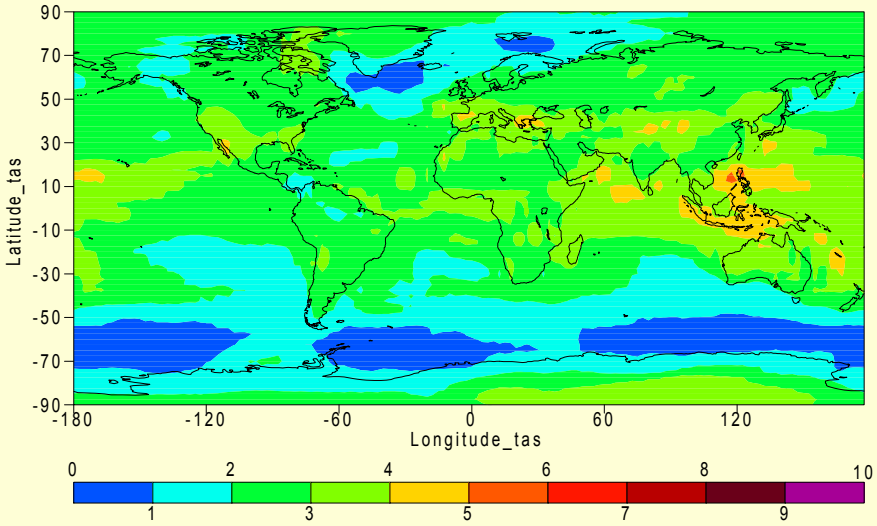


# Inter-Model Signal-to-Noise Ratios in CMIP2 Greenhouse Warming Experiments (1%/year $CO_2$ increase)

Normalized S/N



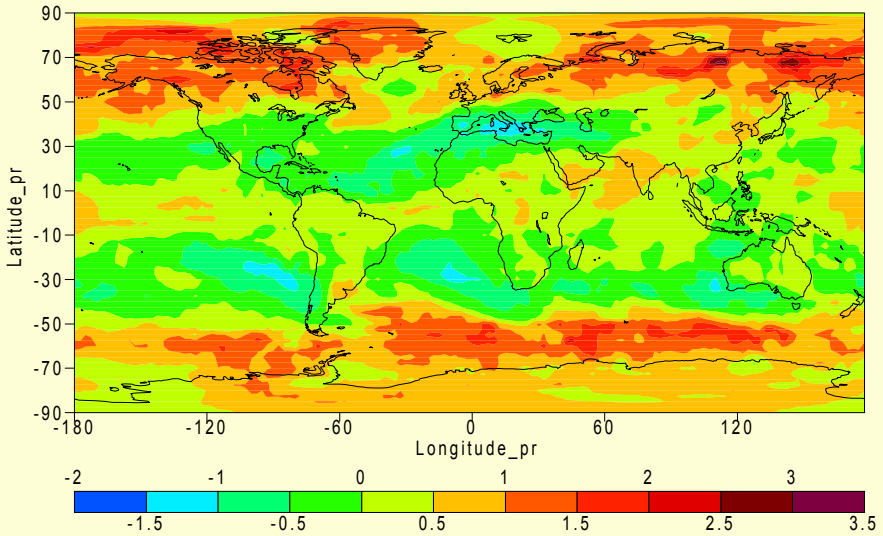

Raw S/N



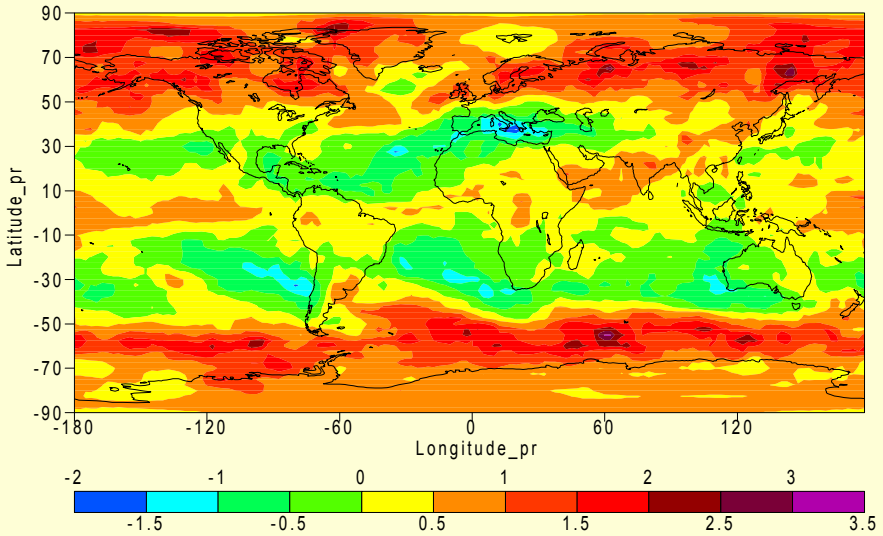

**Surface temperature changes**

# Inter-Model Signal-to-Noise Ratios in CMIP2 Greenhouse Warming Experiments (1%/year $CO_2$ increase)

Normalized S/N




Raw S/N



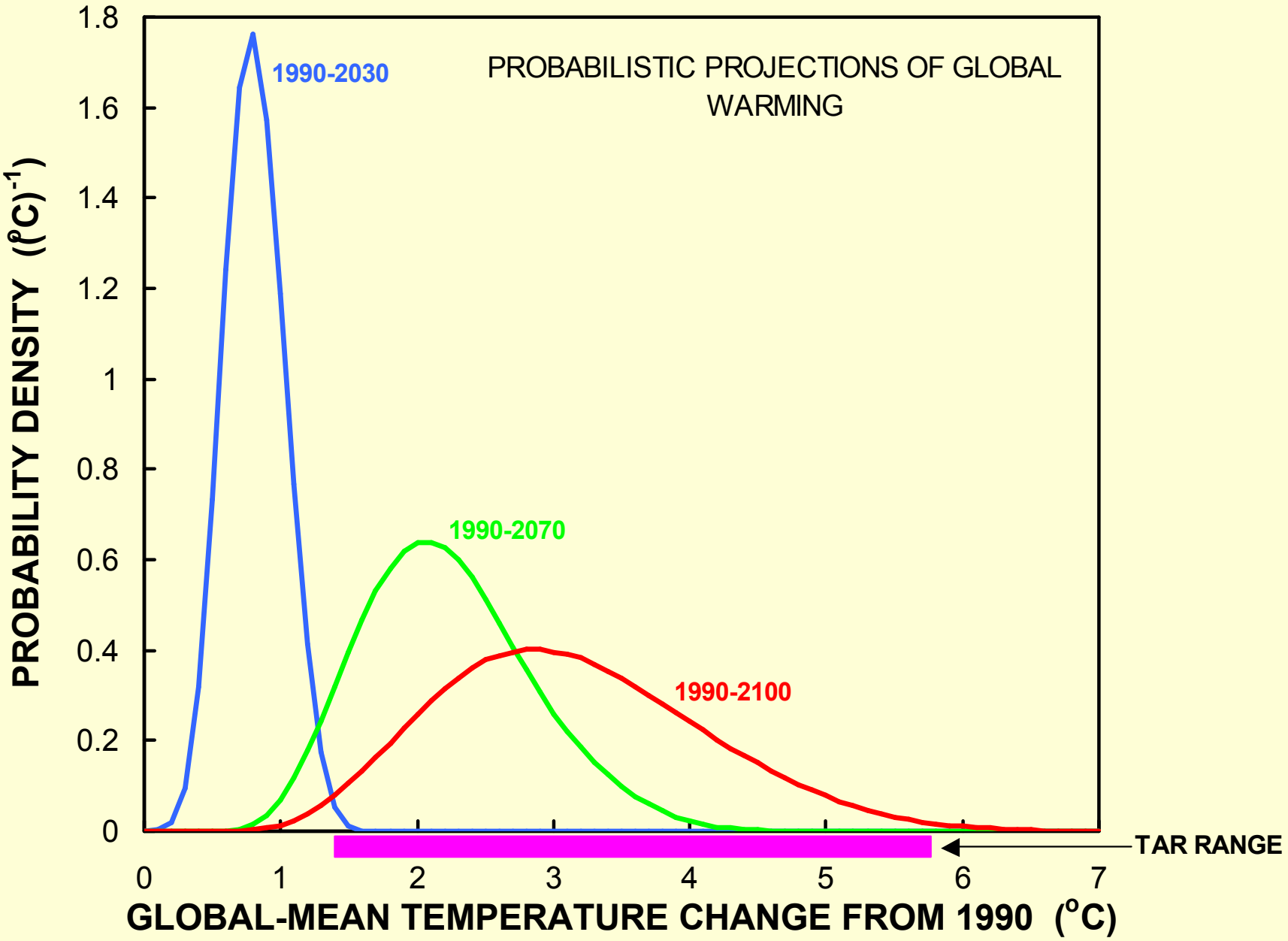

**Changes in total precipitation rate**

# PROBABILISTIC PROJECTIONS OF FUTURE GLOBAL-MEAN WARMING

(from Wigley & Raper, *Science* **293**, 451-454, 2001)

UNCERTAINTIES ACCOUNTED FOR:

(1) Emissions
(2) Climate Sensitivity
(3) Aerosol forcing
(4) Ocean mixing rate
(5) Carbon cycle`


PROBABILISTIC PROJECTIONS OF GLOBAL WARMING
1990-2030
1990-2070
1990-2100
TAR RANGE
PROBABILITY DENSITY ((°C)⁻¹)
GLOBAL-MEAN TEMPERATURE CHANGE FROM 1990 (°C)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
1
2
3
4
5
6
7