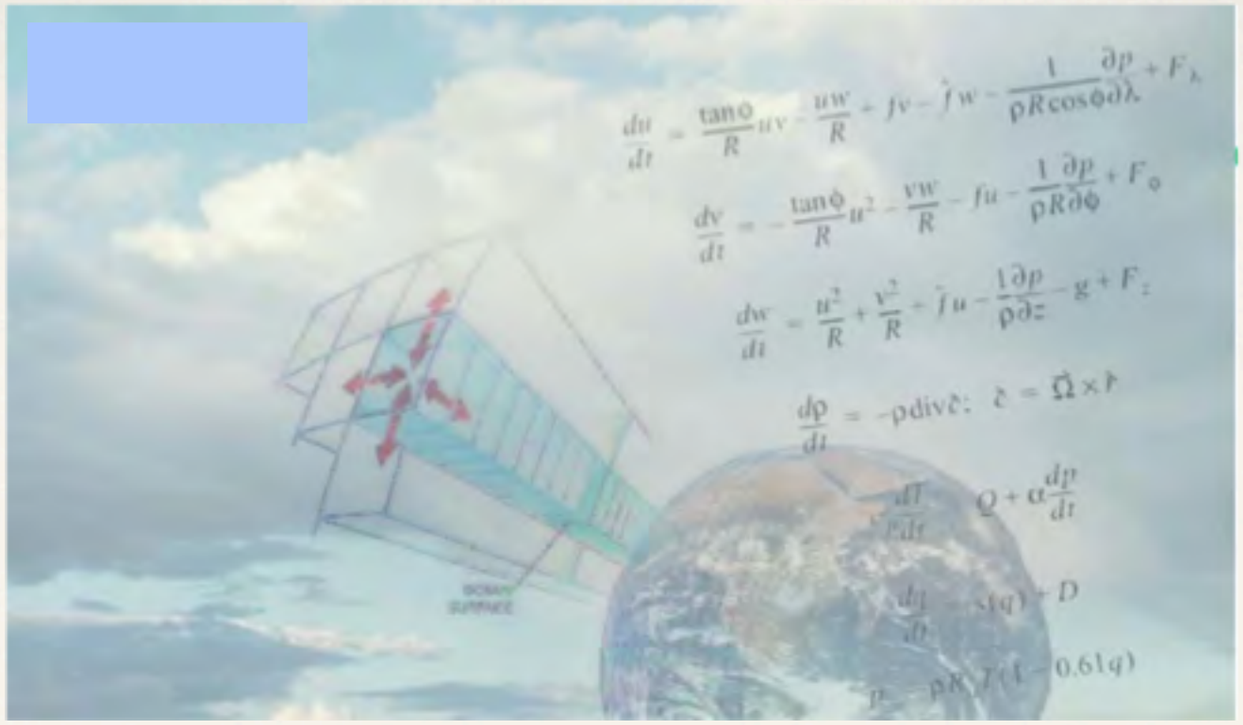


From regional weather to global climate: Progress and Challenges in improving models

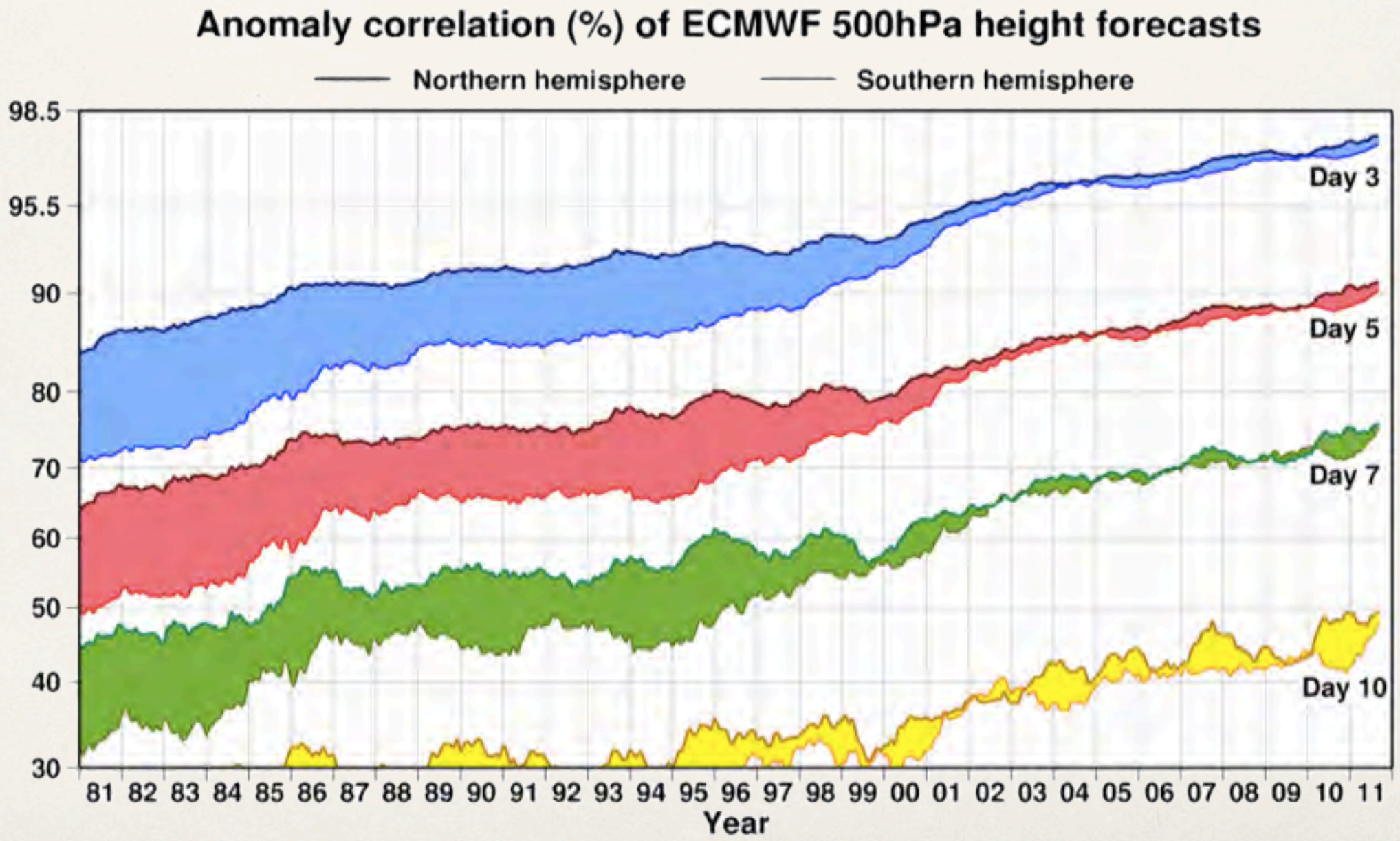
Christian Jakob, ARC Centre of Excellence for Climate System Science, Monash University, Melbourne, Australia

Special thanks: Martin Miller, Andy Brown, Pier Siebesma, Sandrine Bony, Neville Nicholls, Adrian Simmons, Judith Perlwitz, and a whole lot more people

Some starting points

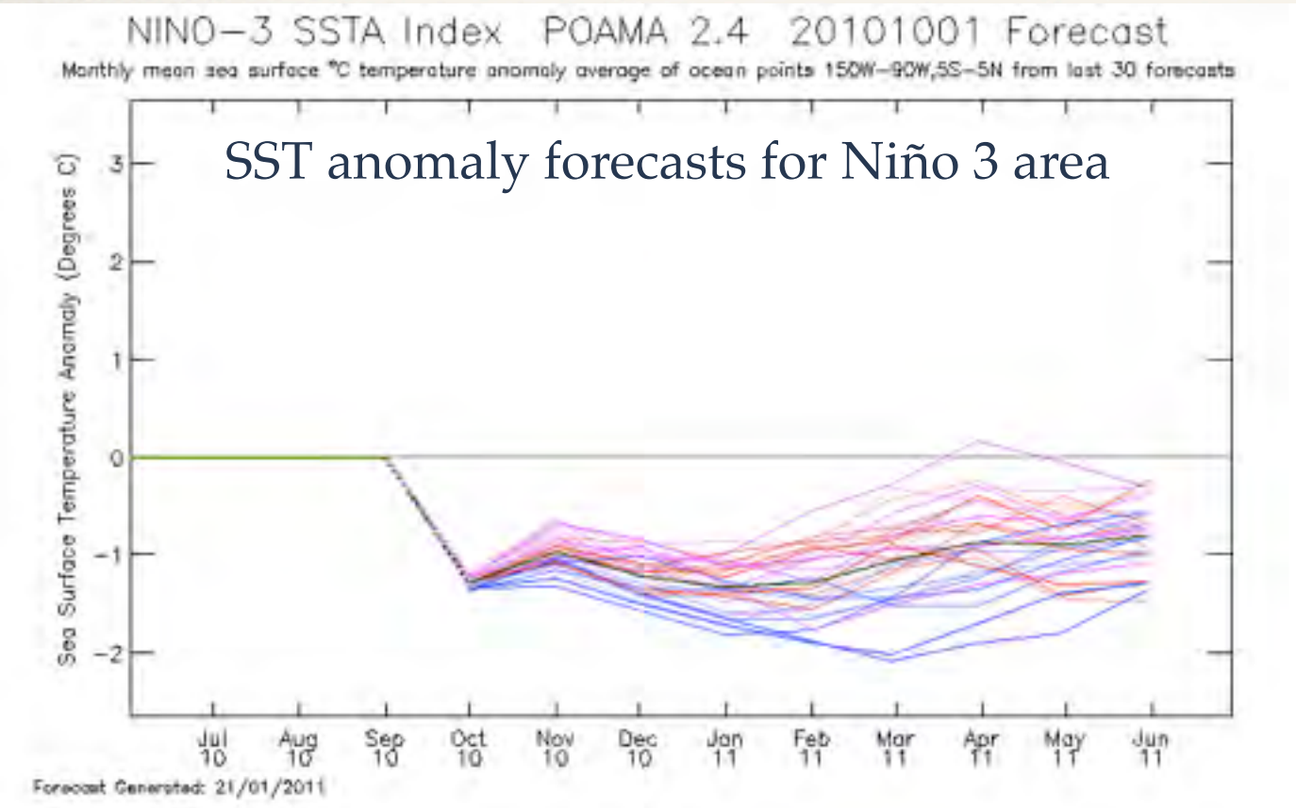
- Weather and climate models save lives!
- Weather and climate models save property and billions of dollars a year!
- Weather and climate models underpin some of the most critical decisions made by society for the near and far future!
- Weather and climate models have revolutionised the world, a revolution that has gone largely unnoticed!
- However, key issues remain and require a significant transformation of the community to be resolved.

The “unnoticed” revolution

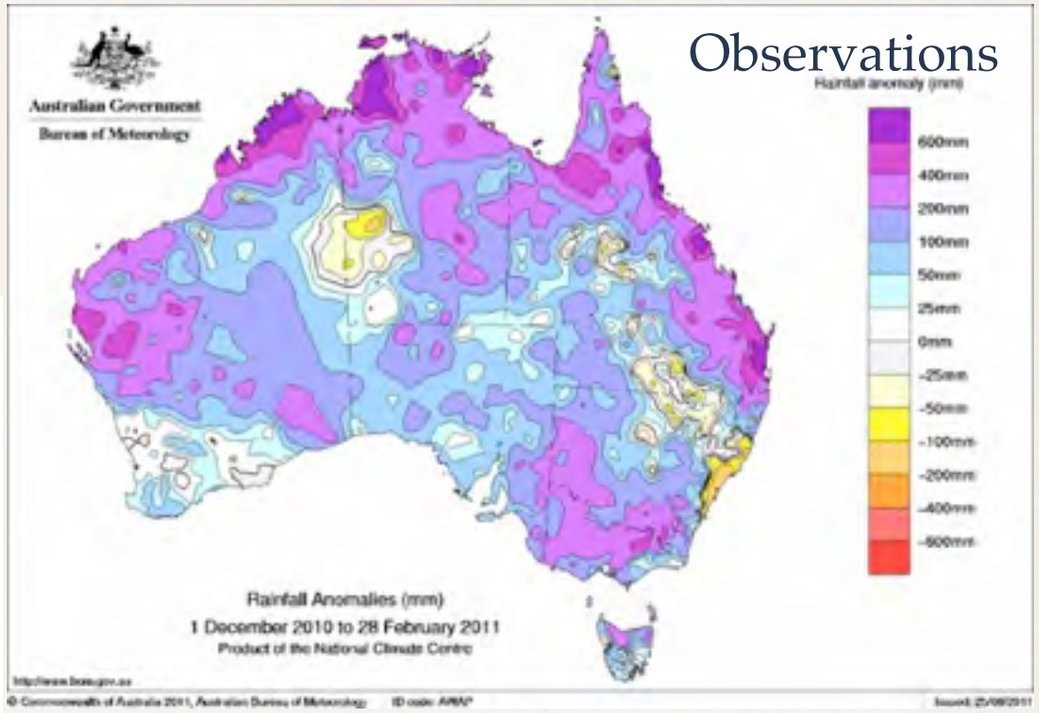


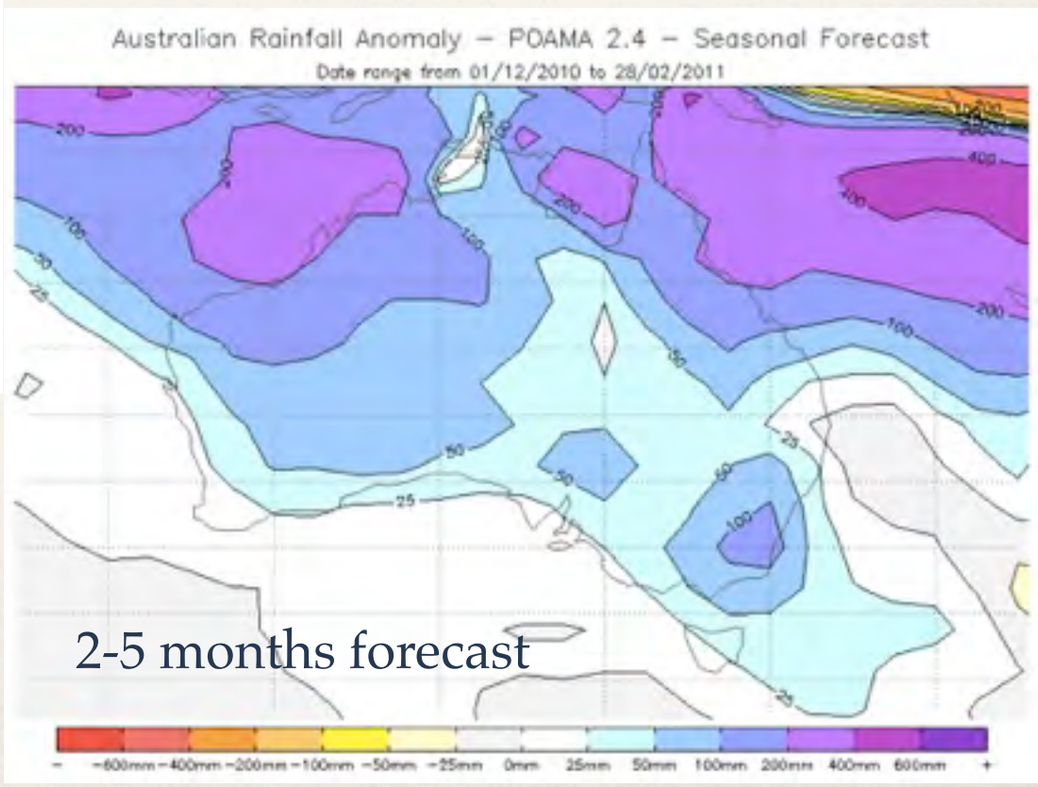
Courtesy of ECMWF. Adapted and extended from Simmons & Hollingsworth (2002)

The "unnoticed" revolution



SST anomaly forecasts for Niño 3 area



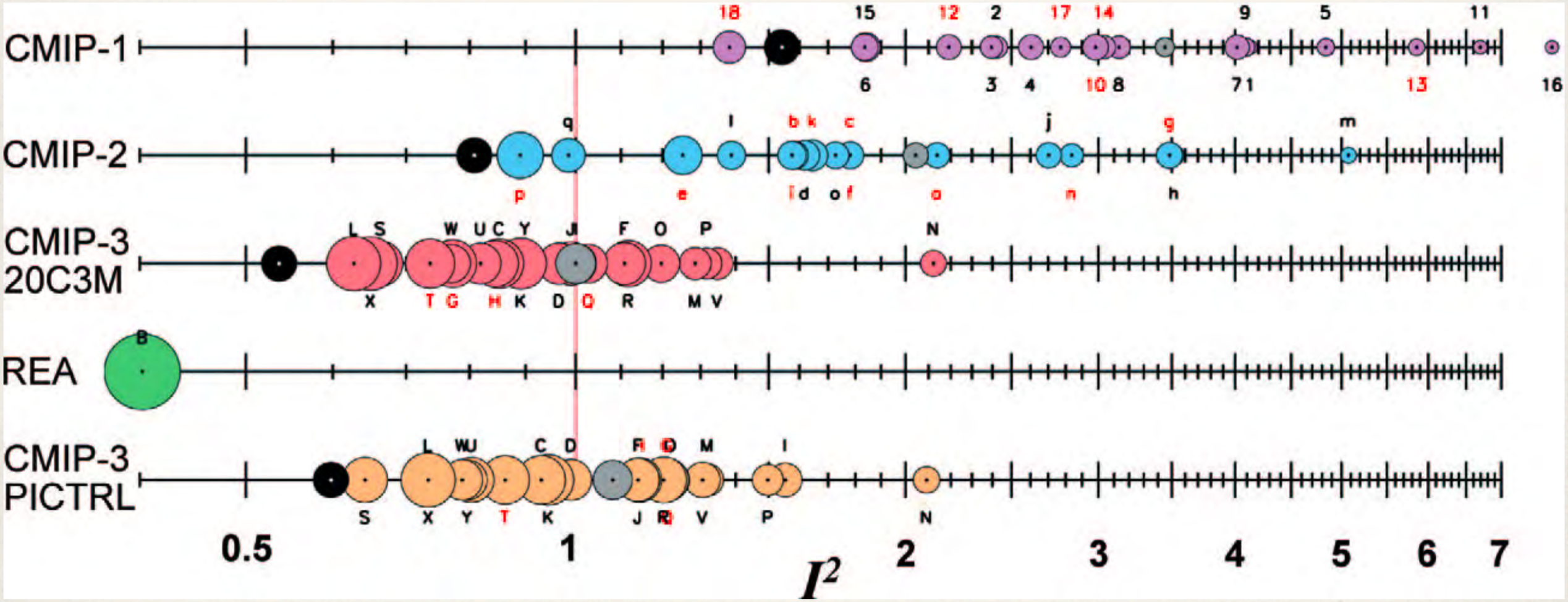


2-5 months forecast

Courtesy POAMA team, CAWCR, Australia

The "unnoticed" revolution

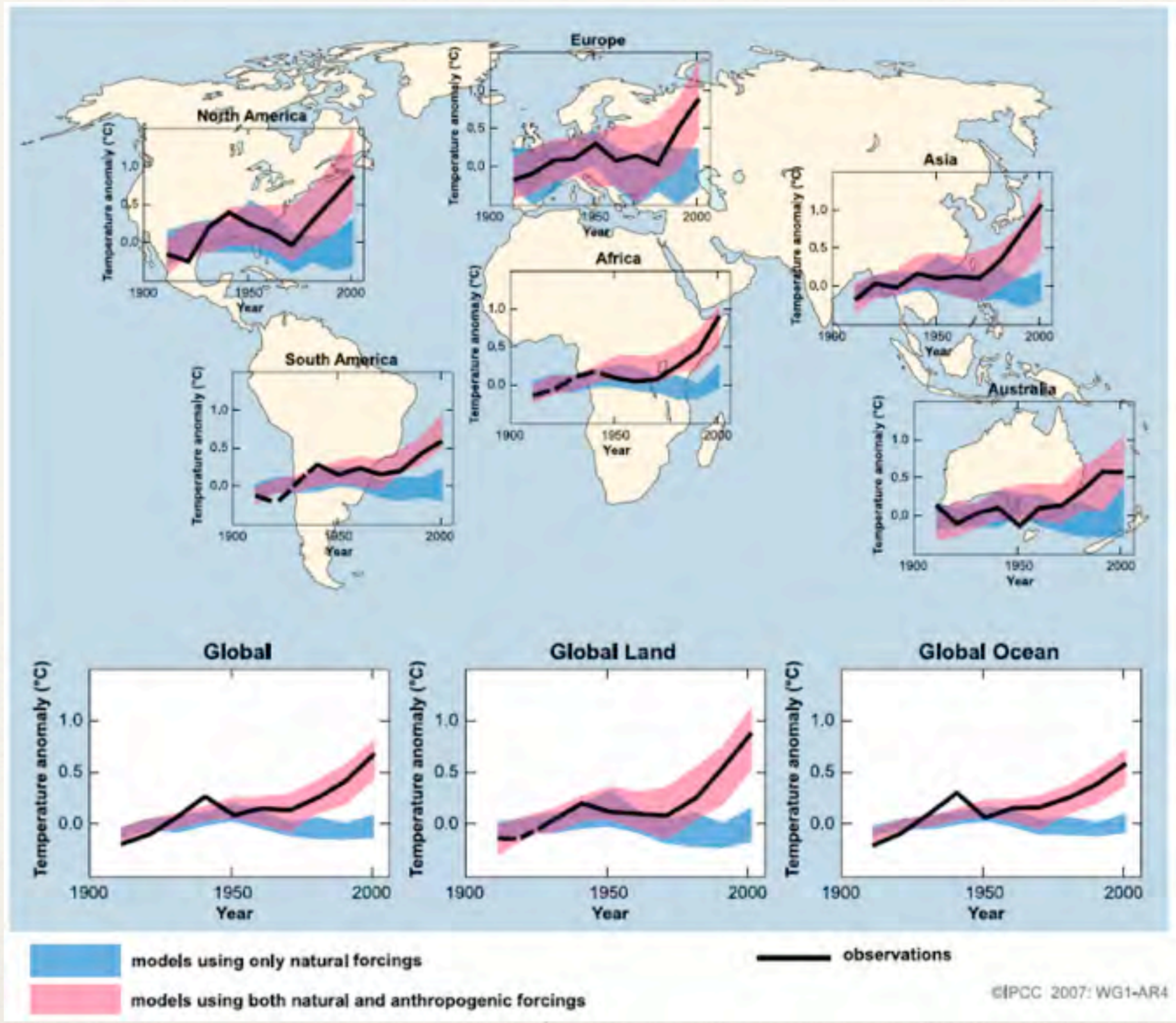
Climate model skill



Better skill

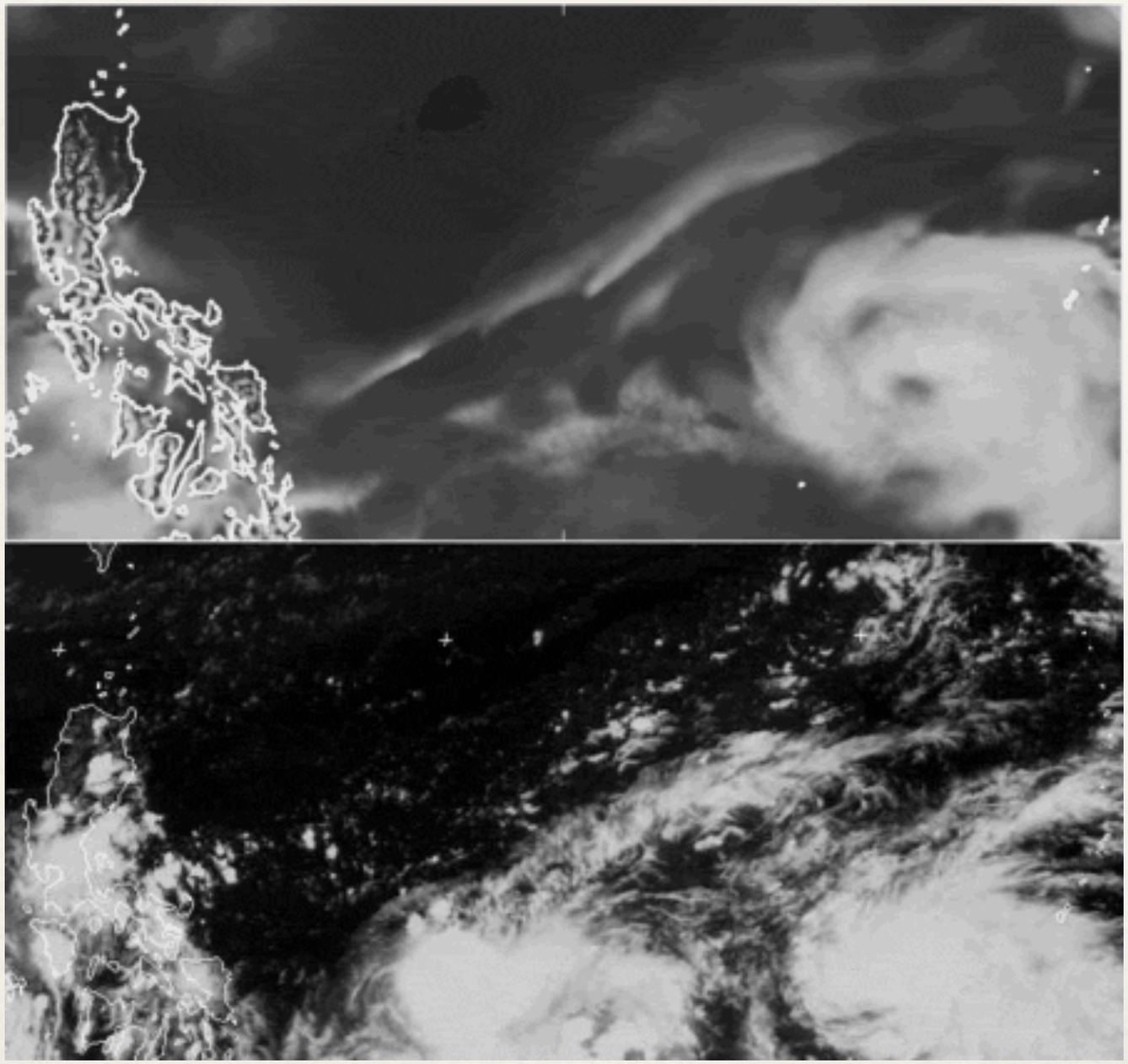
Reichler and Kim, 2008

The "unnoticed" revolution



IPCC, 2007

The “unnoticed” revolution

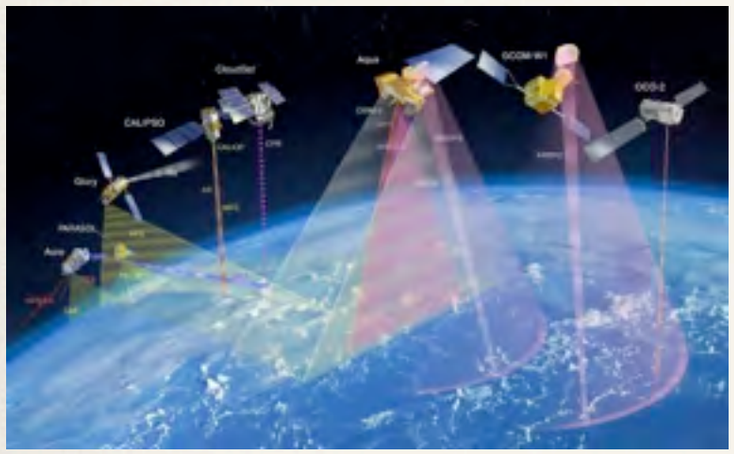


1.5 km resolution simulation of Typhoon Megi

Courtesy of UK MetOffice

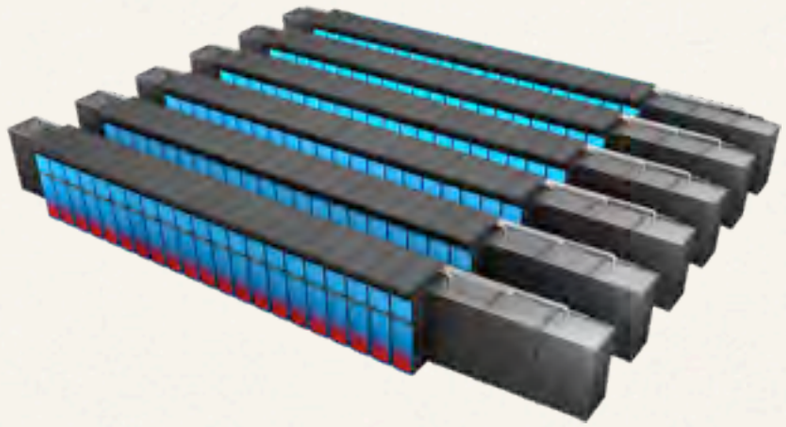
Opportunities

Observations



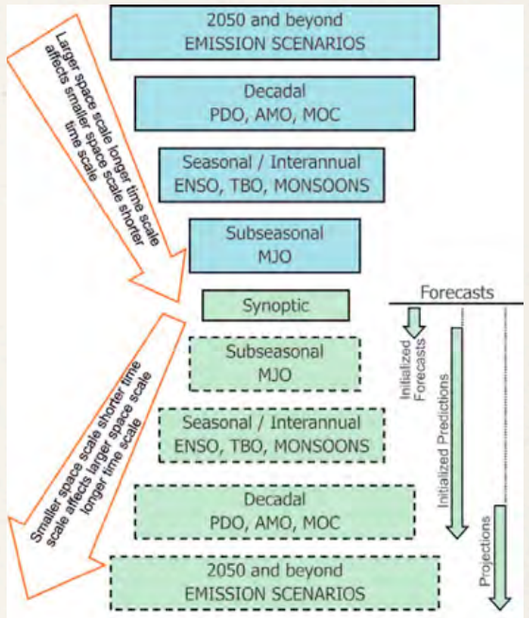
Courtesy NASA

Computing



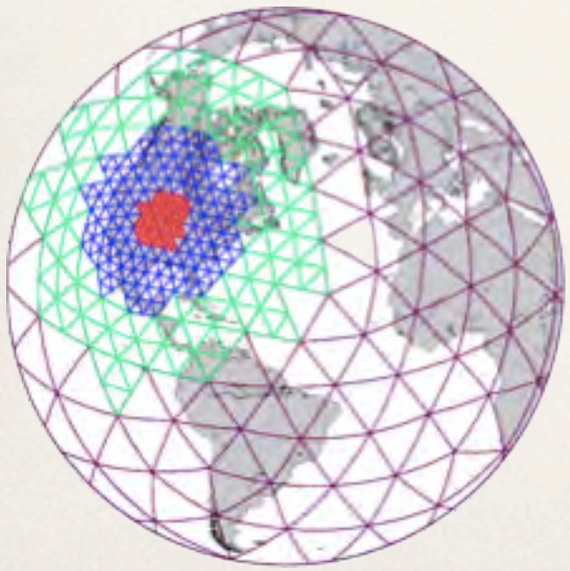
Courtesy J Hack (ORNL)

The seamless approach



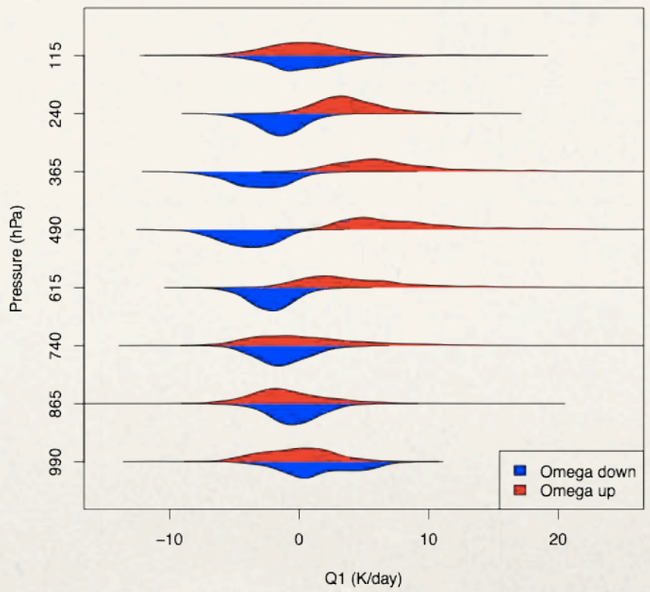
Hurrell et al, BAMS 2009

New numerics



Courtesy DWD

New physics



Jakob et al., ECMWF, 2011

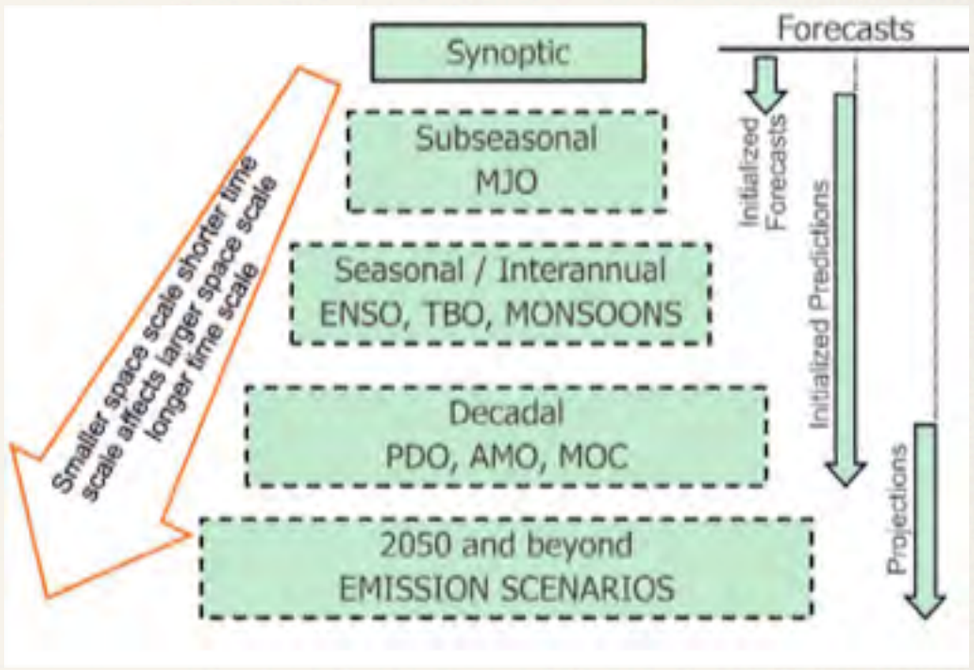
A community

Courtesy WMO

Challenges - The expectations

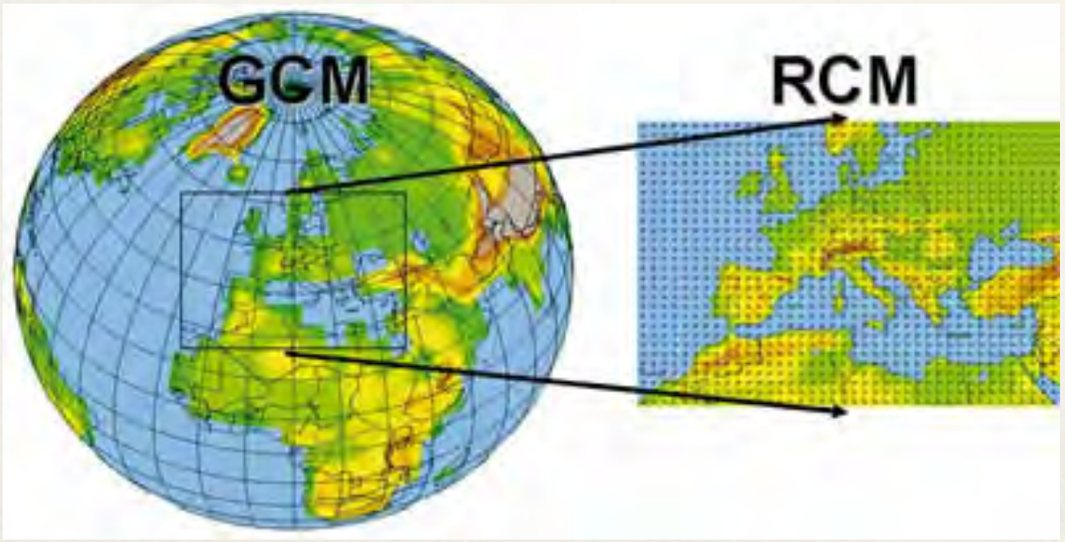
Predict weather not just flow

Extend the range of useful predictions



Hurrell et al, BAMS 2009

Support adaptation and mitigation decisions

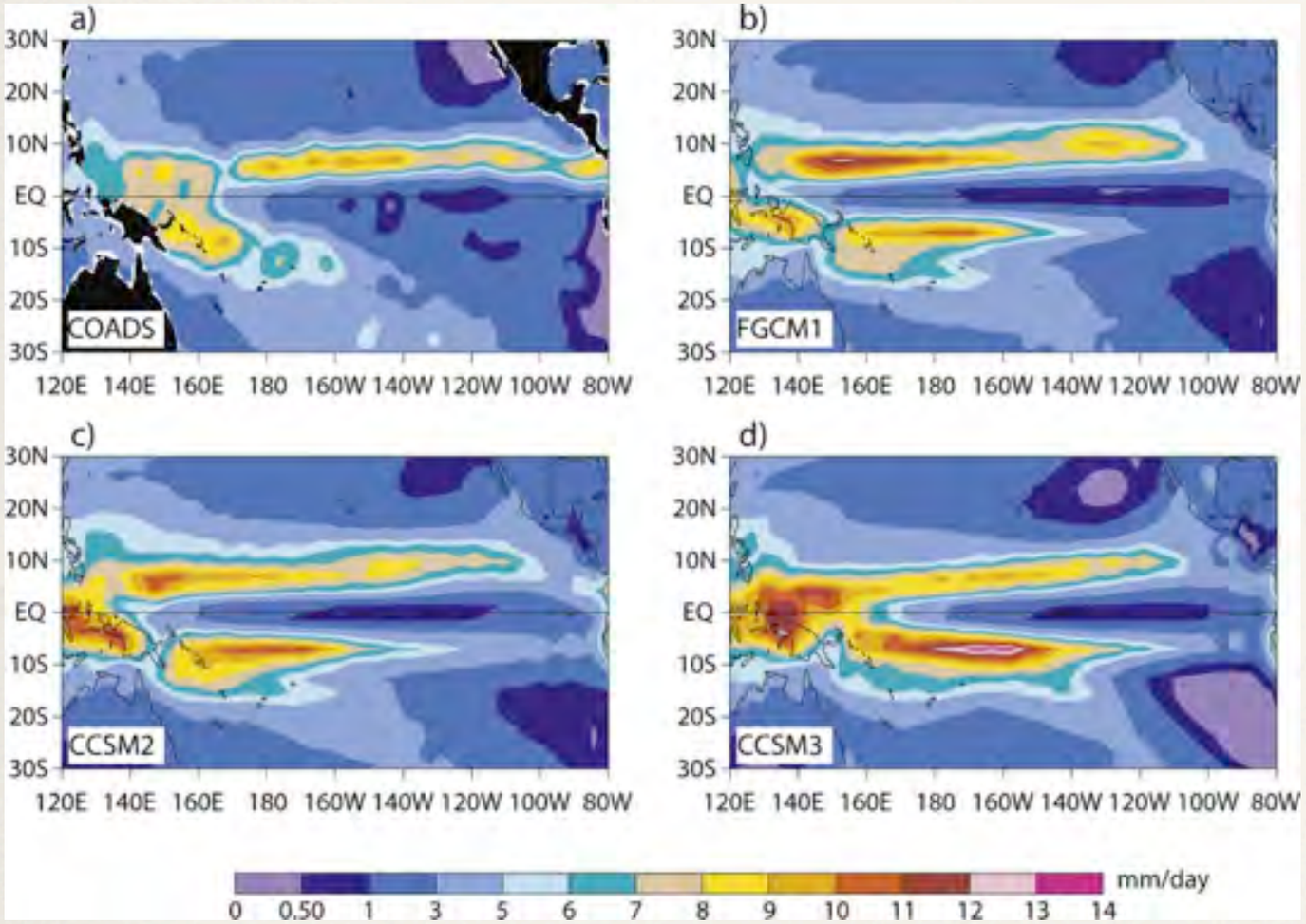


Courtesy of WMO


Tropical Cyclones
Monsoon
Madden-Julian Oscillation
Indian Ocean
Tropical Depressions
El Niño / La Niña
West Coast Trough
Upper Level Trough
Trade Winds
Sub-tropical Ridge
L
Cut-off Lows
Northwest Cloudbands
Easterly Trough
East Coast Lows
H
Blocking Highs
L
Frontal Systems
Southern Annular Mode

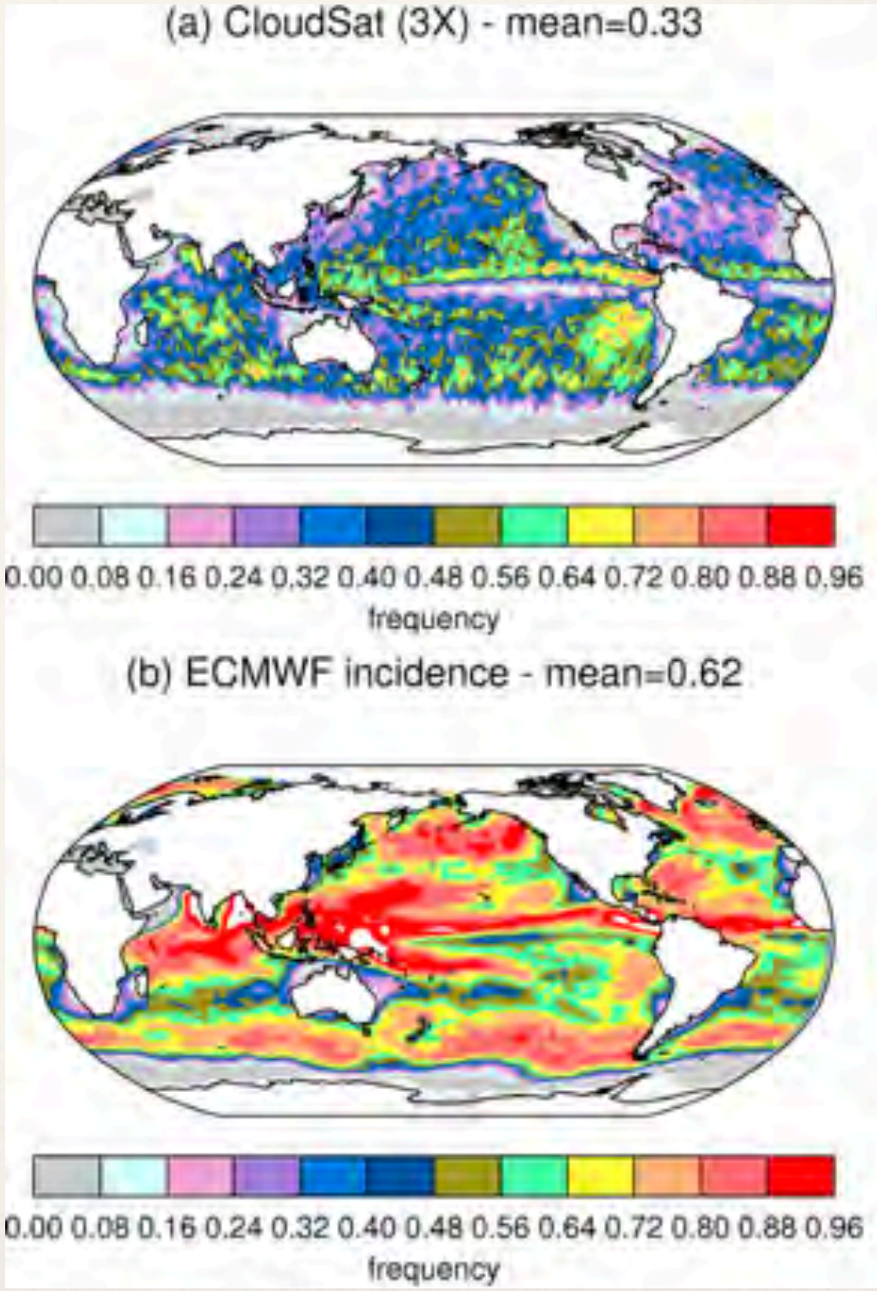
Challenges - Model performance

Mean rainfall distribution



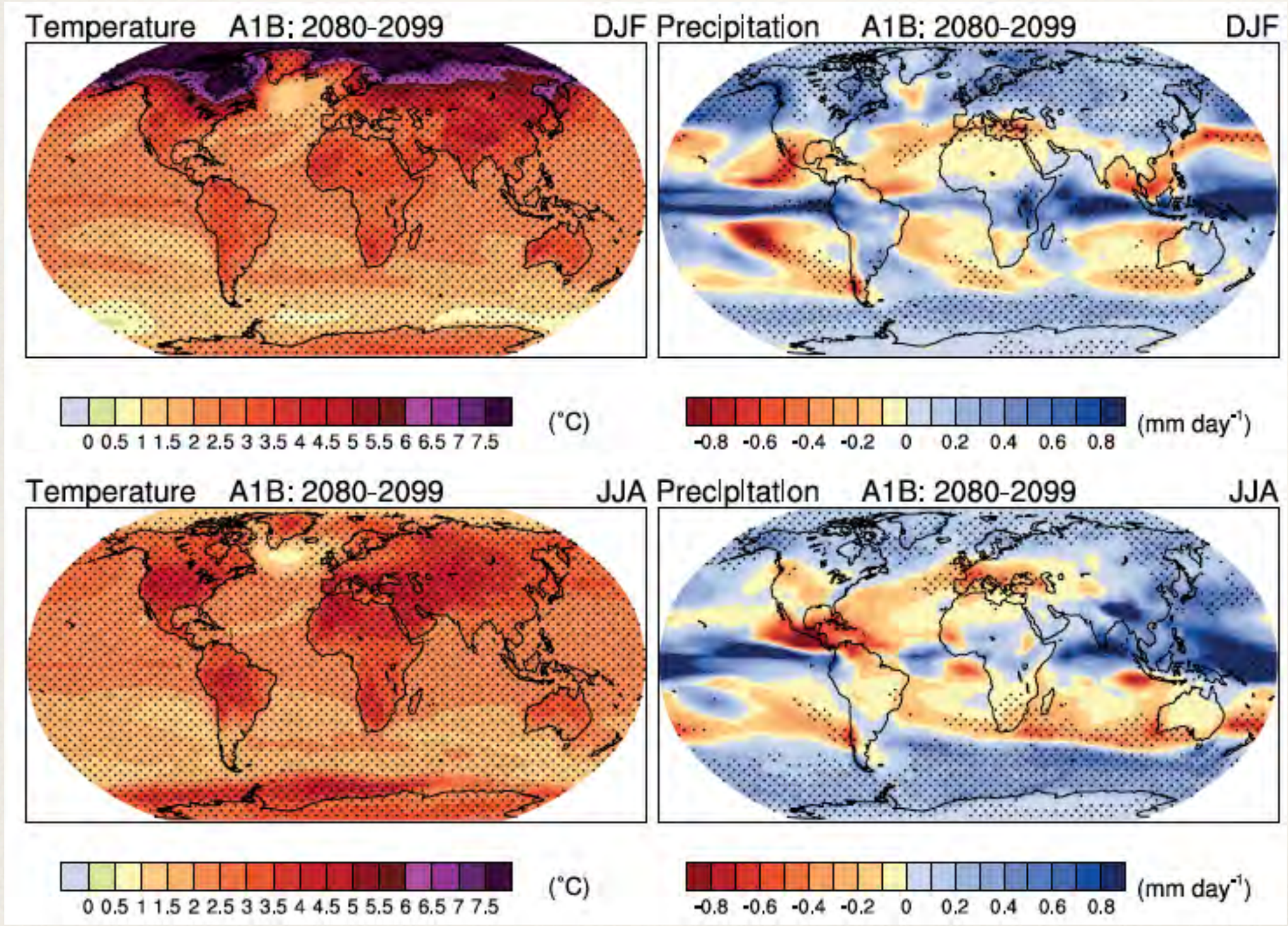
Zhang et al., JGR 2007

Rainfall frequency



Stephens et al., JGR 2010

Challenges - Model performance



IPCC, 2007

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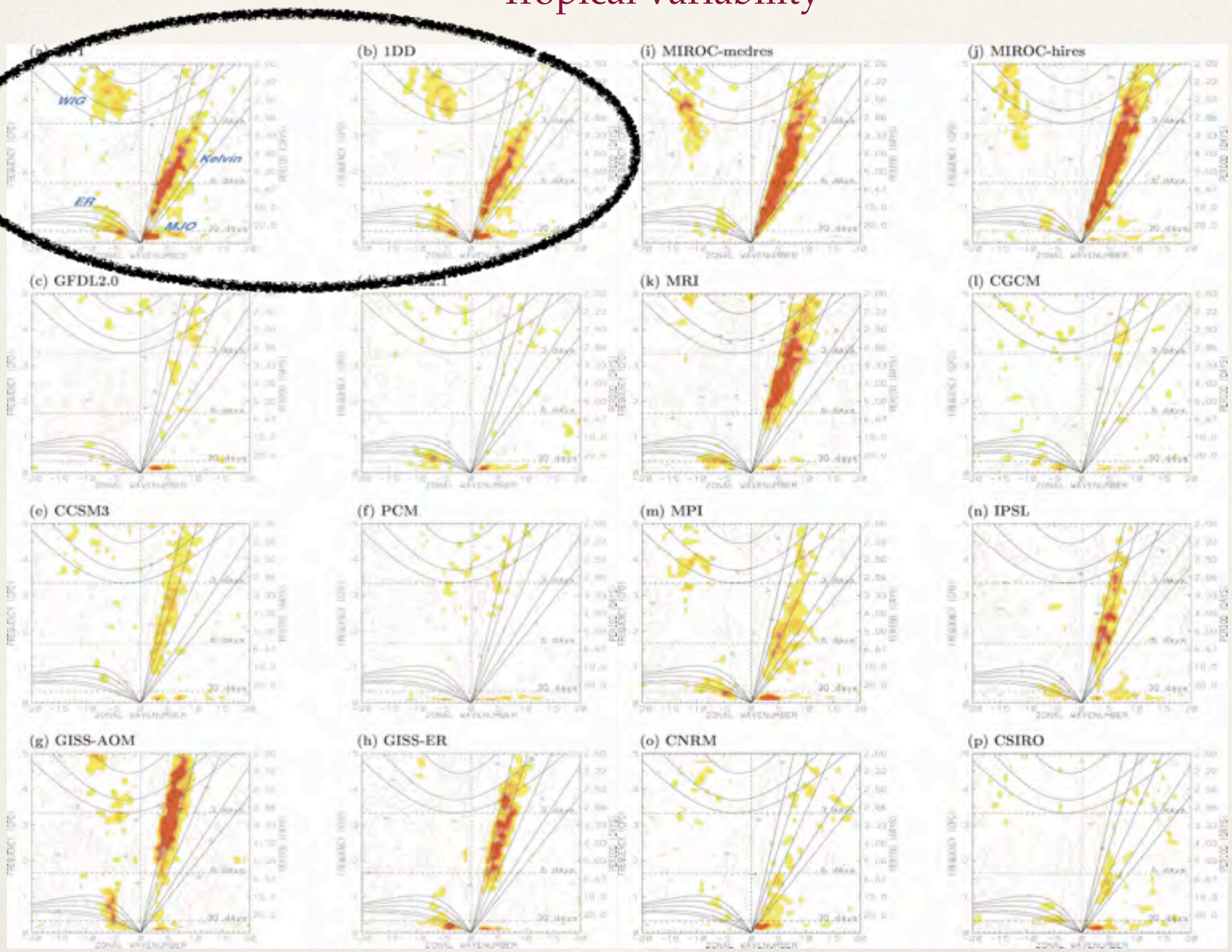
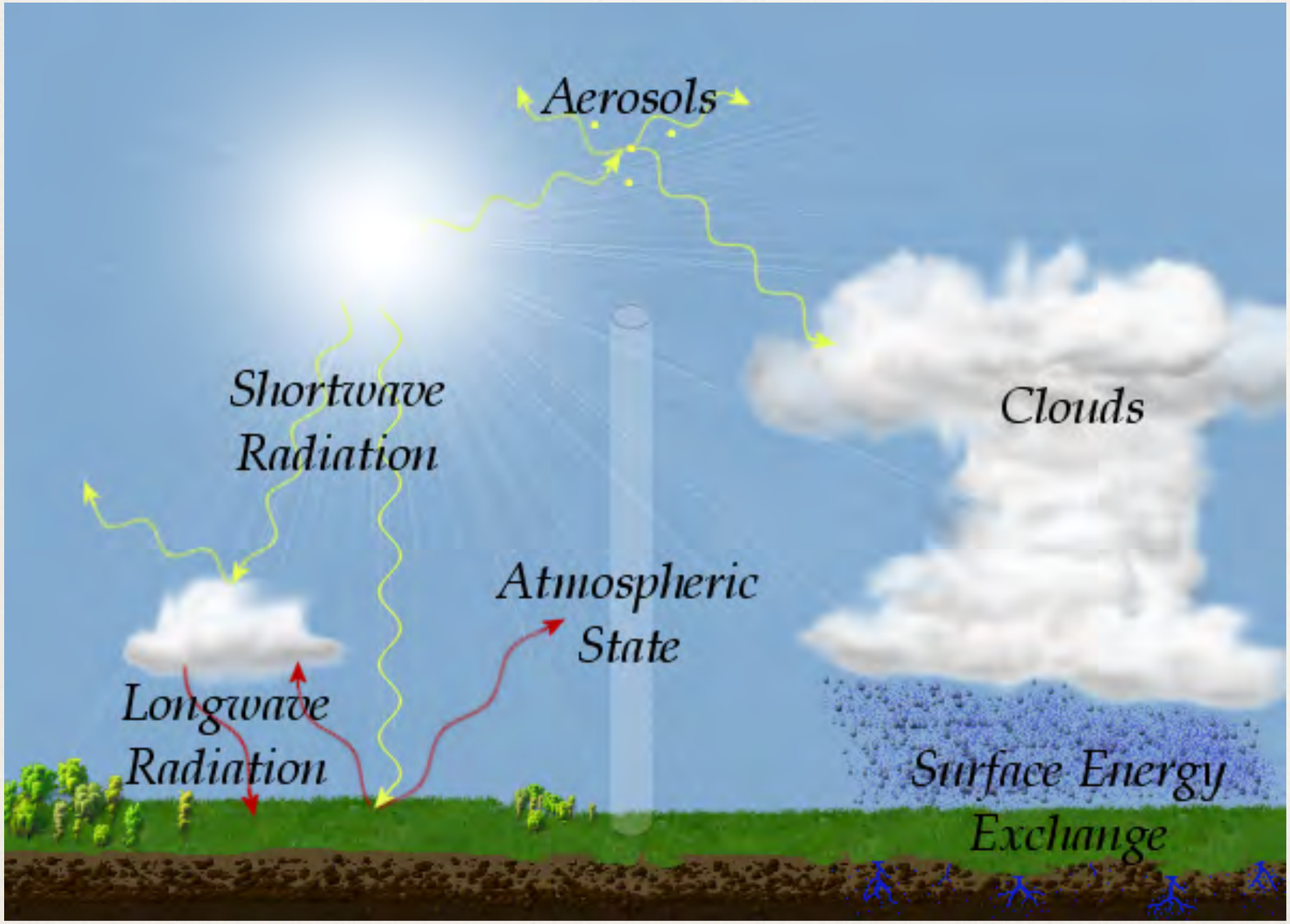
Challenges - Model performance

Tropical variability



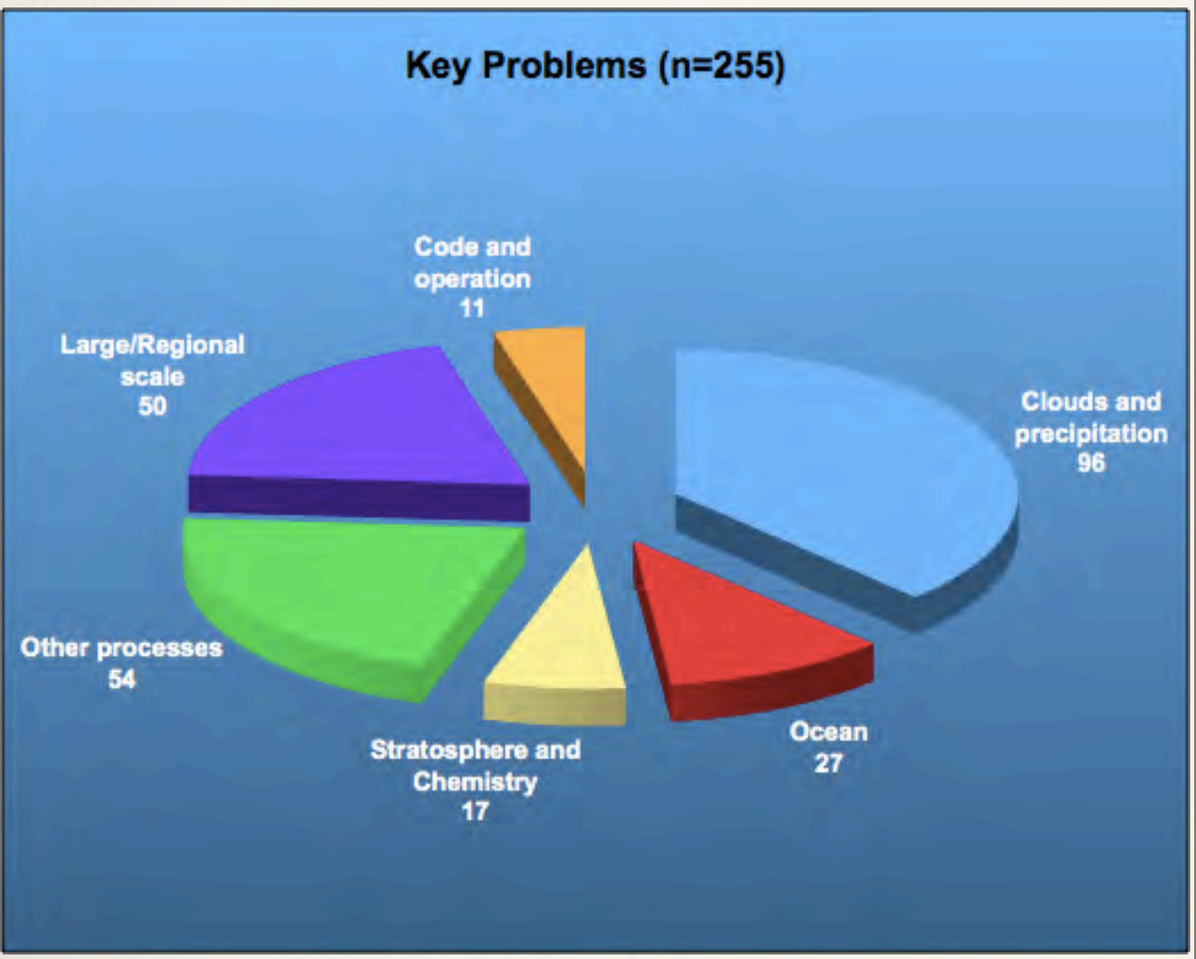
Lin et al., JGR 2006

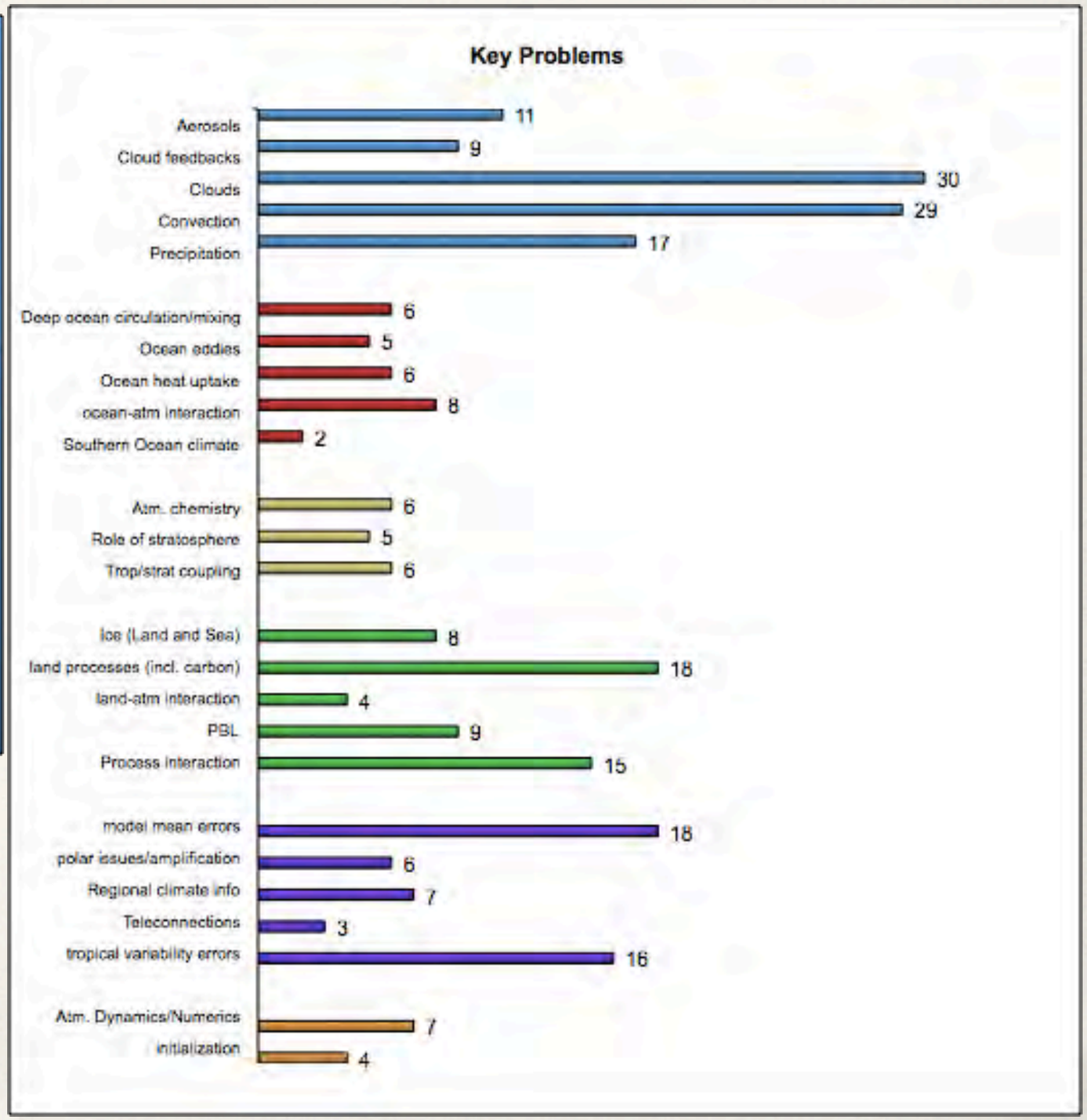
Challenges - Parametrized processes



Source: DOE ARM program

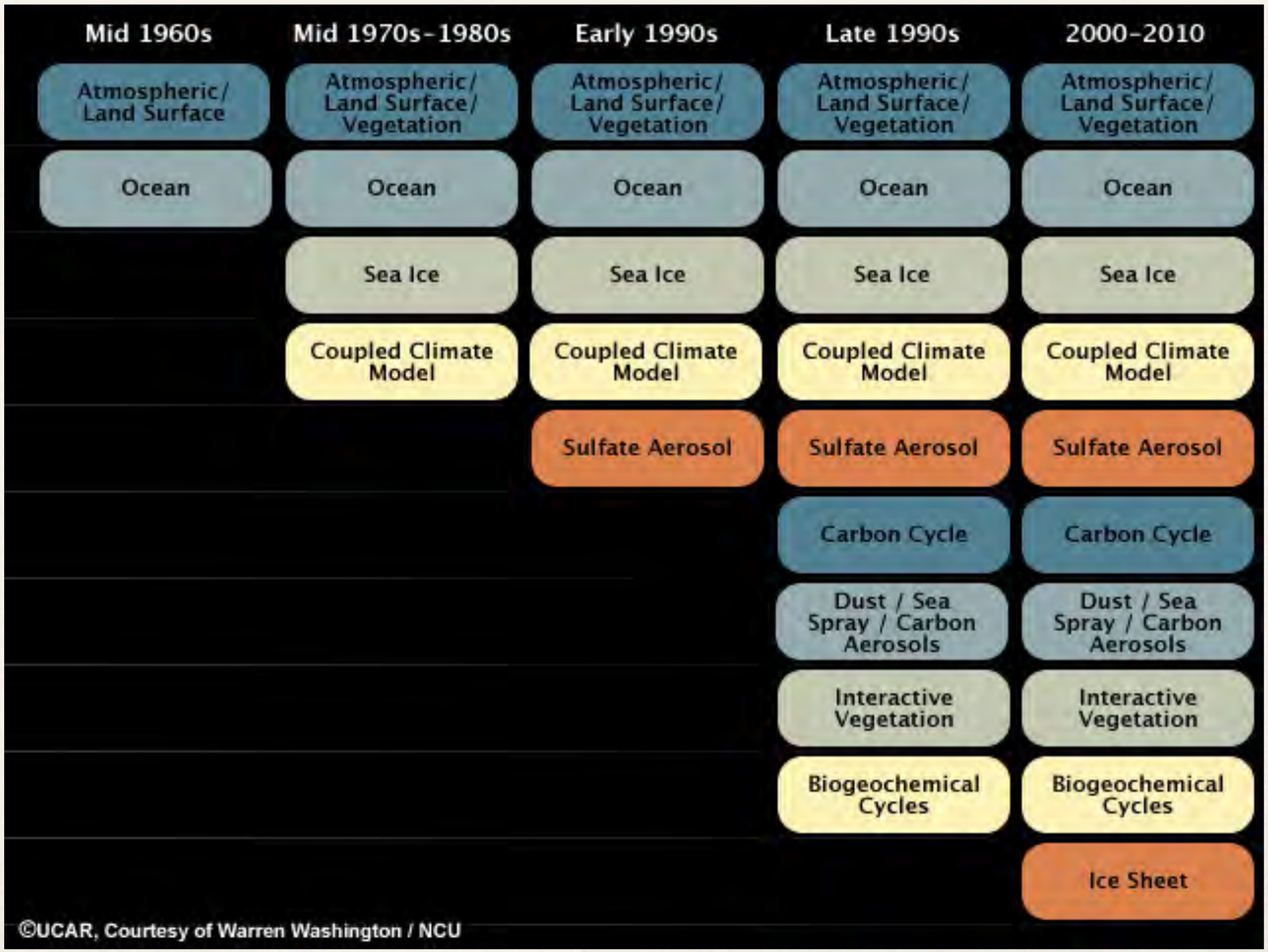
A survey on key model issues





> 130 responses, some by individuals, many by groups, most major centres are represented

Model complexity



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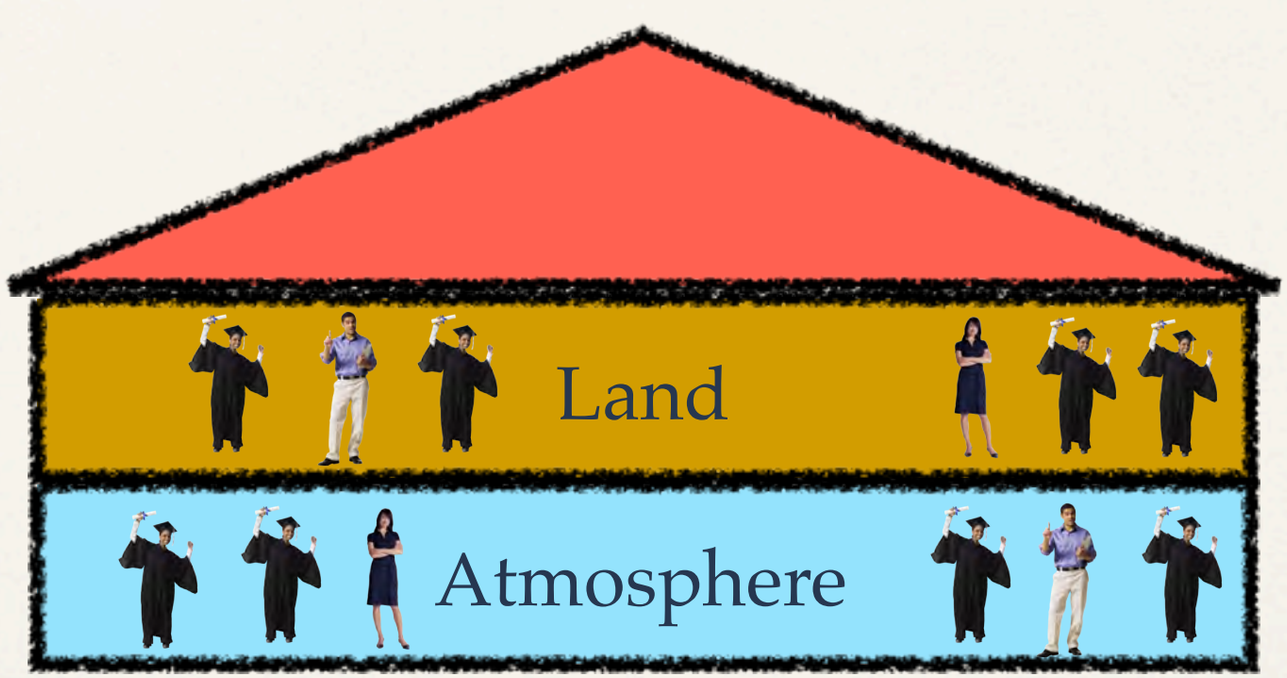
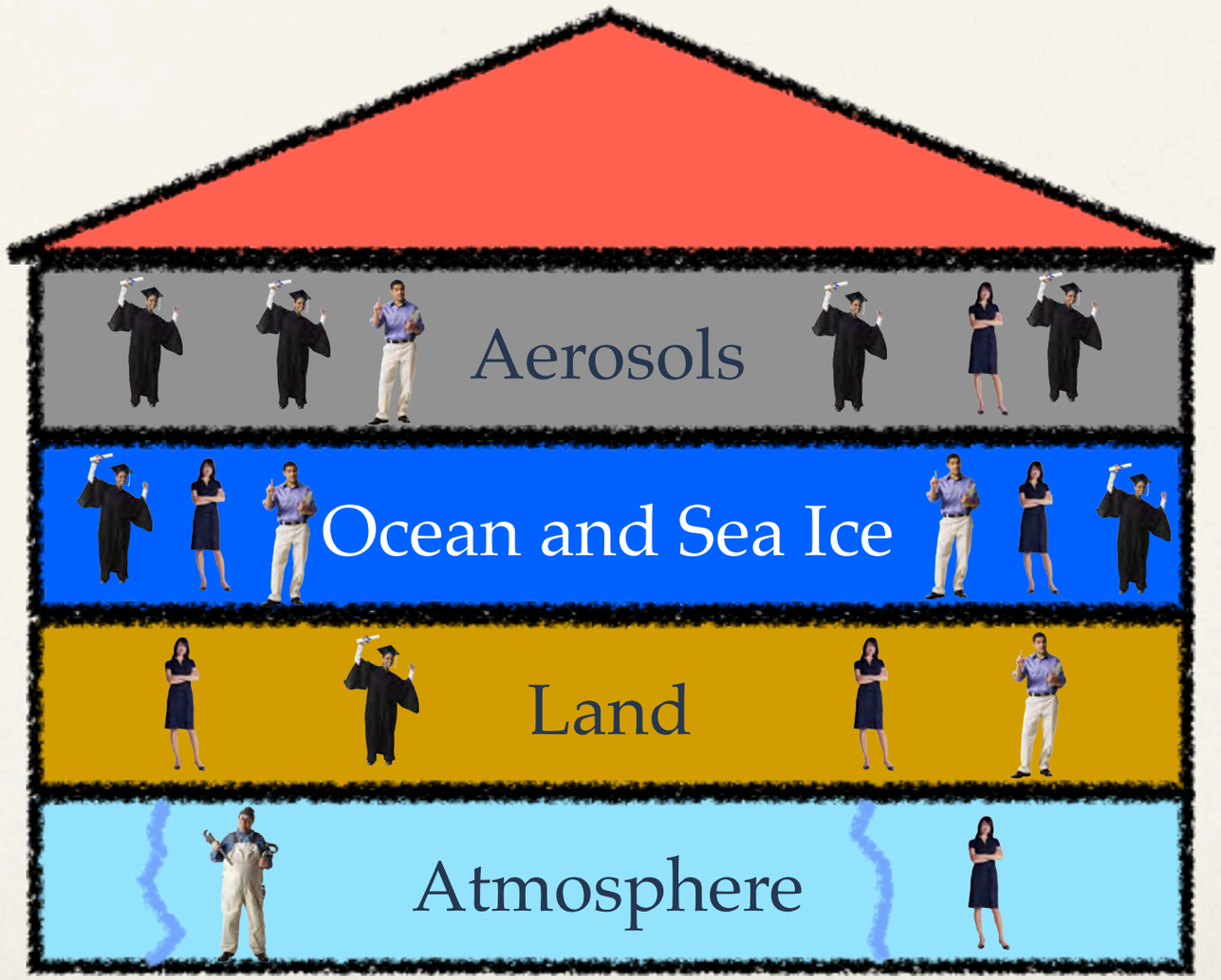
Model complexity

The Seventies and Eighties



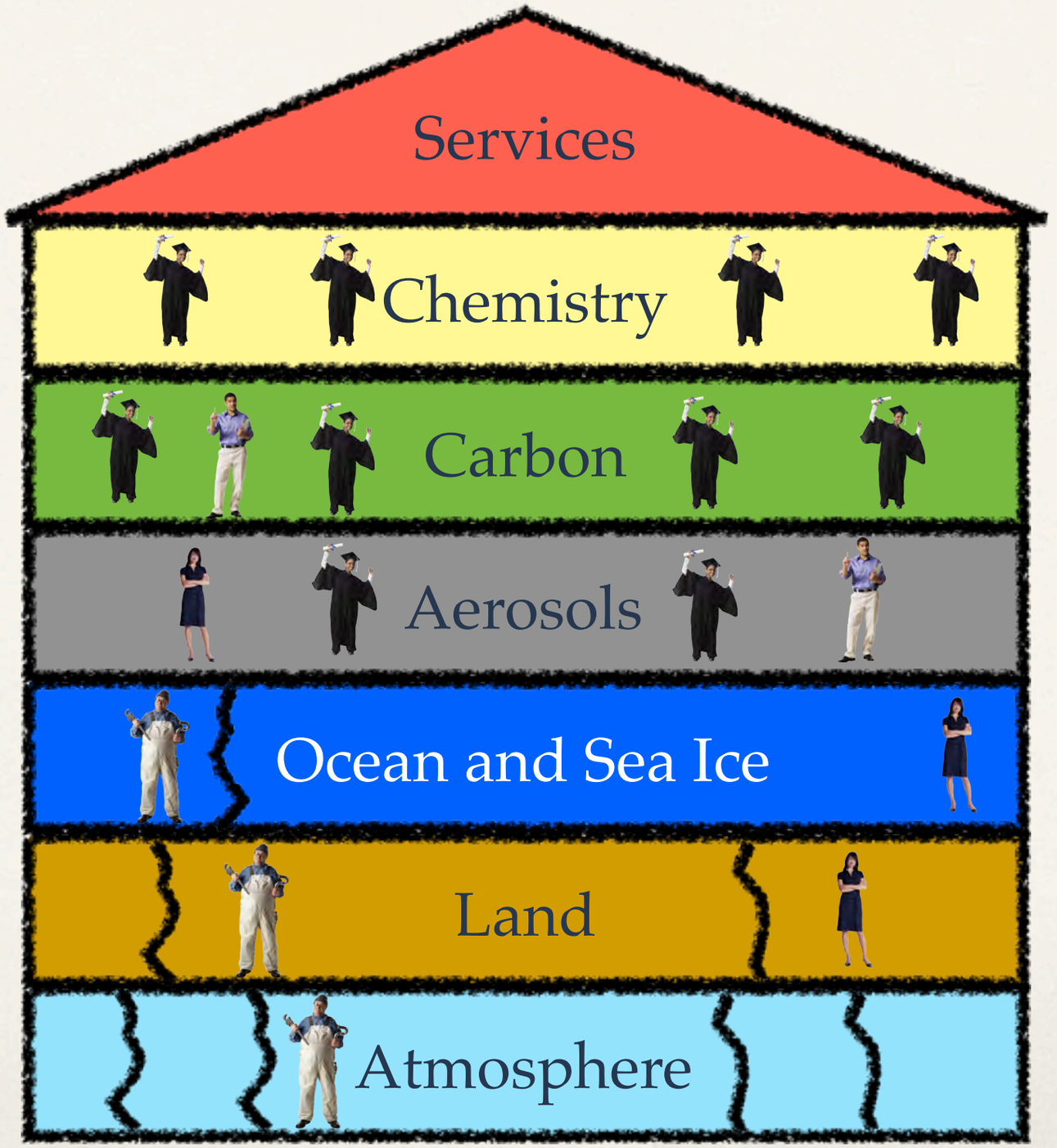
Model complexity

The Eighties and Nineties



Model complexity

Today



Solution 1

Strengthen the foundations of the existing house.

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Science

?

?

Physical Model developer

Tasmanian Devil

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"An endangered species is a population of organisms which is at risk of becoming extinct because it is either few in numbers, or threatened by changing environmental or predation parameters." - Wikipedia

?

Physical Model developer

Tasmanian Devil

Endangered Species

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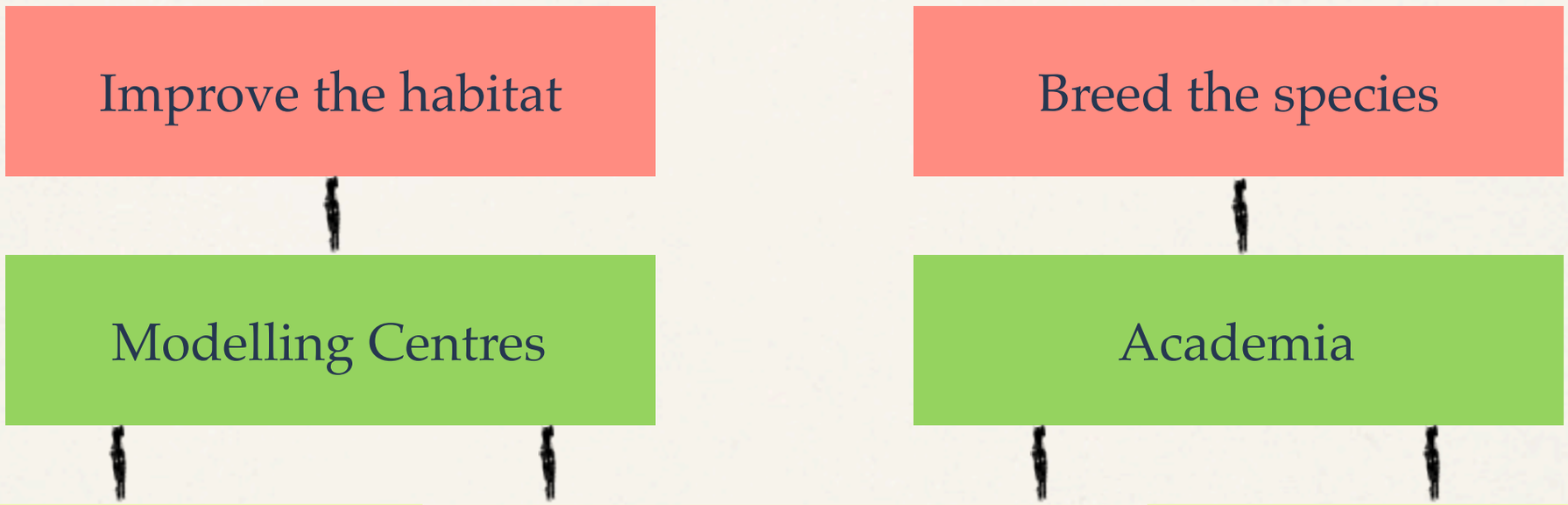
An endangered species program



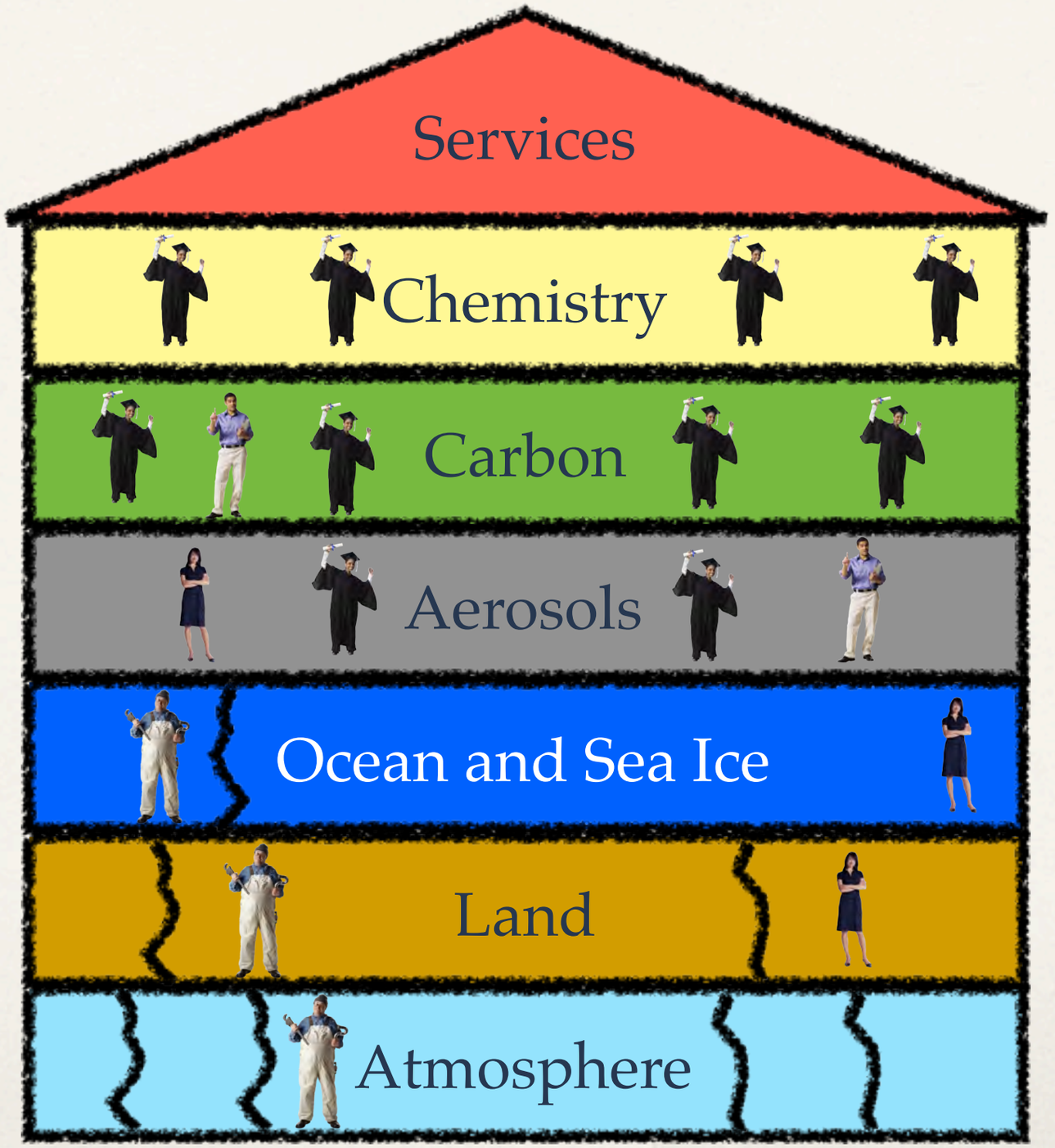
- Open the models to the community
- More internal collaboration
- Reward system

- Stronger formal links
- Joint PhD to guaranteed Postdoc positions
- Strategic partnerships with funding programmes

- Special scholarships
- Model development chairs
- Reward system

Model complexity

Today



Solution 2

Build a new, more modern house, with foundations of the required strength.

A "Manhattan project"

- Improved models are key to achieving the skill of predictions society is asking of us.

- This calls for a "Manhattan-style" project on developing the best model we can today.

- The main purposes of such a project would be to advance the science of modelling and to demonstrate the effect on key predictions.

- Must build a new model using modern ideas (e.g., stochastic approaches, high-efficiency and high-resolution dynamical cores, ...).

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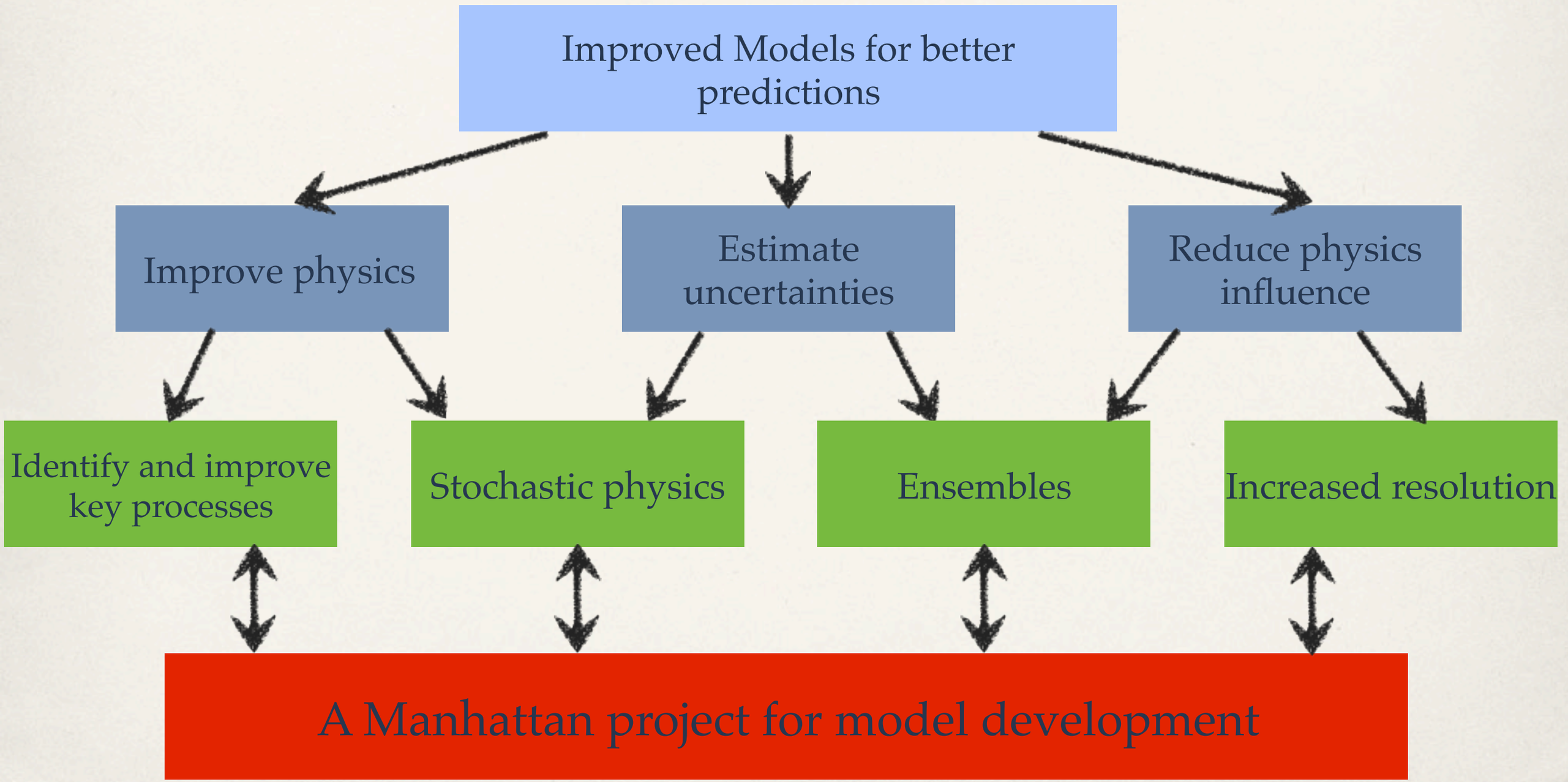
A "Manhattan project"

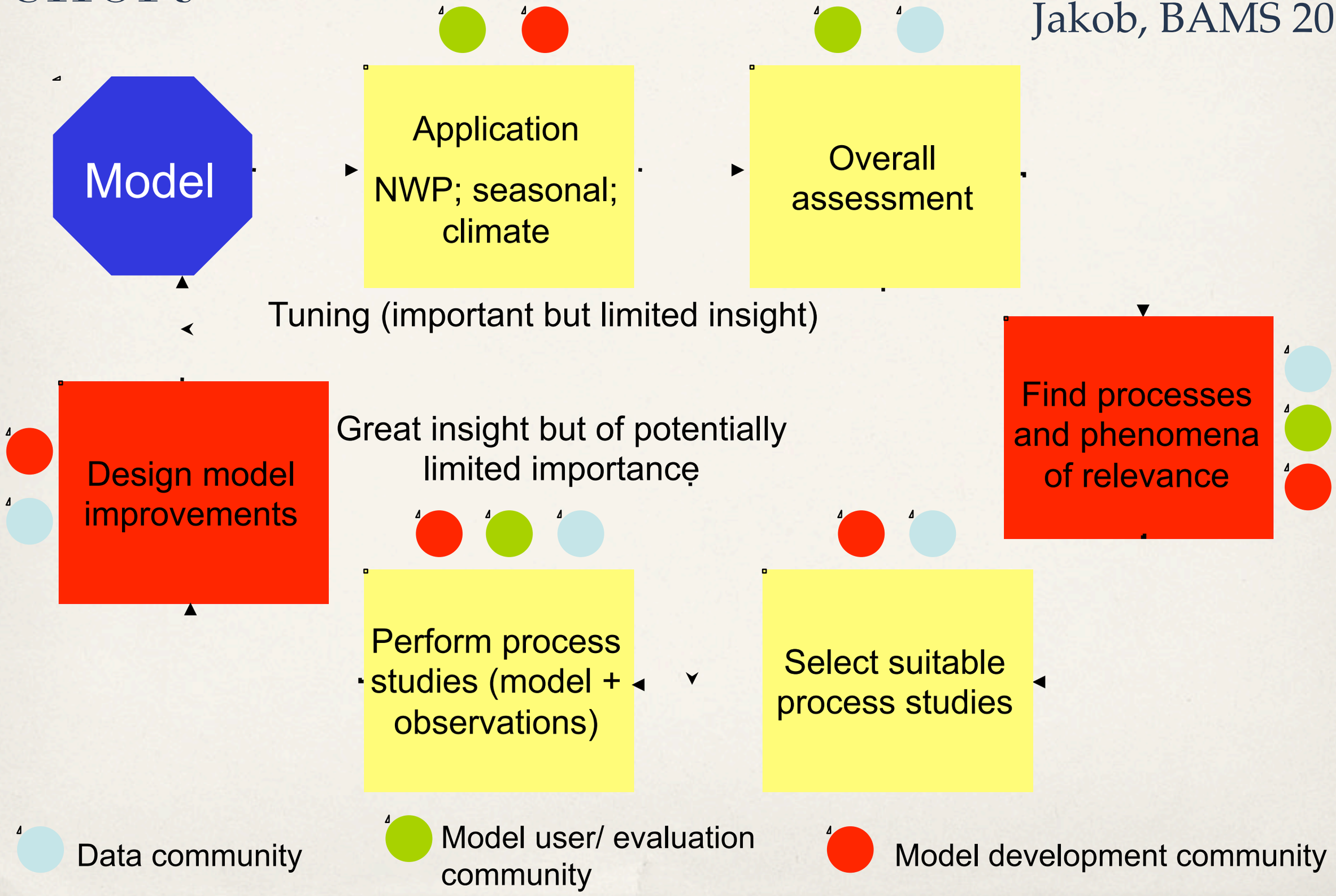


A "Manhattan project"

- Model development should not be undertaken in isolation from prediction
- Option 1: Link the project with a few existing modelling centres
- Option 2: A new centre, say for seasonal to decadal prediction
- Could be centralised or distributed

Model development is a community effort

Jakob, BAMS 2010



Summary

- Weather and climate models underpin some of mankind's greatest endeavours. They save lifes. They save property. They affect all aspects of society.

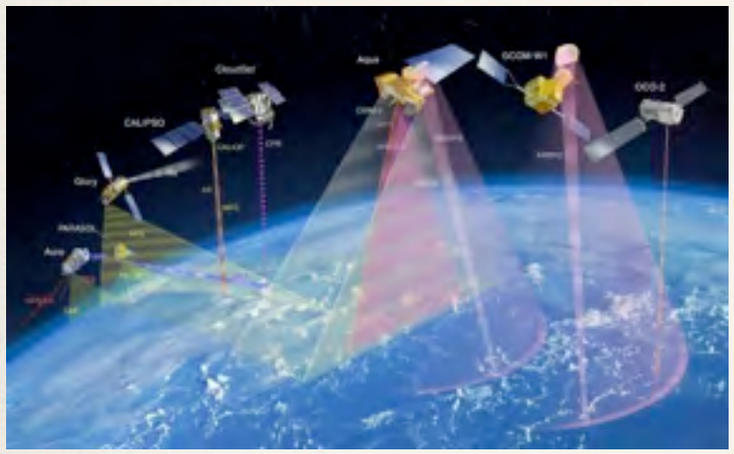
- Improvements in forecasts and projections have been underpinned by improvements in models - Future improvements require renewed and increased investment in basic model development.

- Models have become increasingly complex, but some key issues have not been resolved. We need both an endangered species program for model developers and our own "Manhattan"-style project to successfully implement the seamless prediction paradigm.

- The time is right!

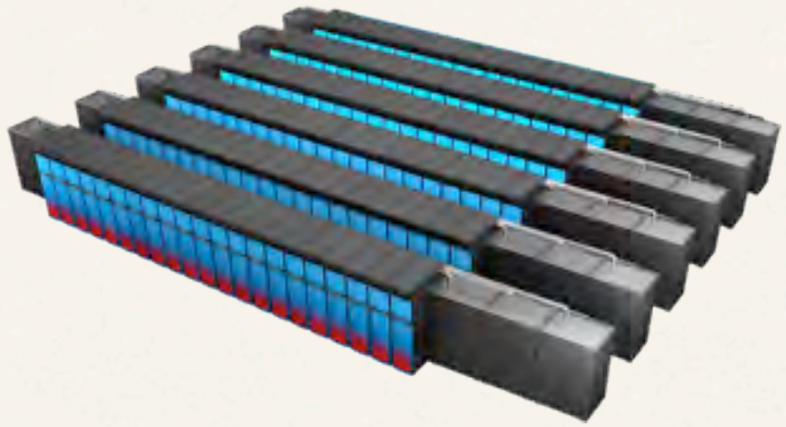
Opportunities

Observations



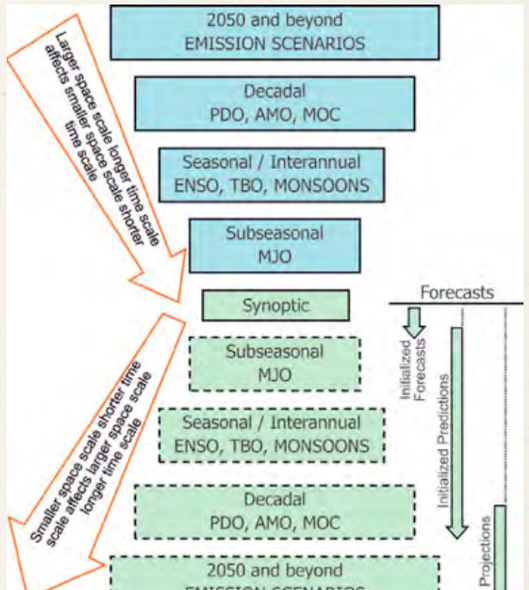
Courtesy NASA

Computing



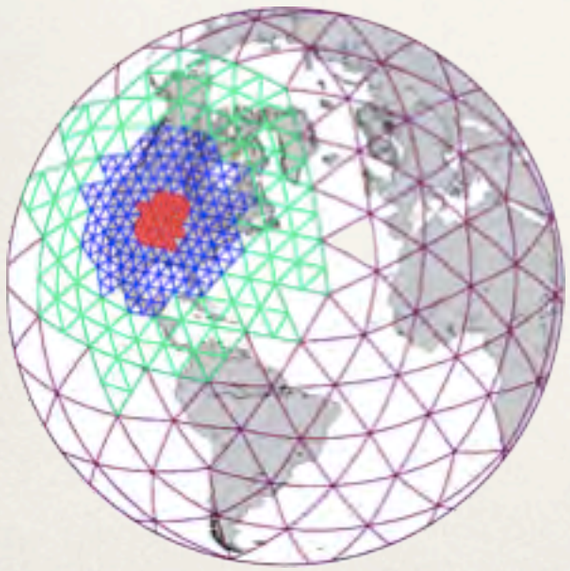
Courtesy J Hack (ORNL)

The seamless approach



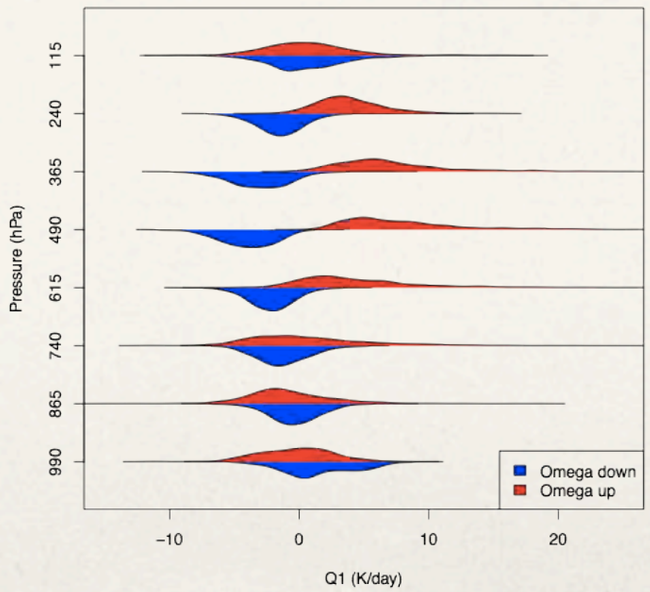
Hurrell et al, BAMS 2009

New numerics



Courtesy DWD

New insights



Jakob et al., ECMWF, 2011

A community

Courtesy WMO