Observations for the evaluation of the multi-scale aspects of the water cycle in models

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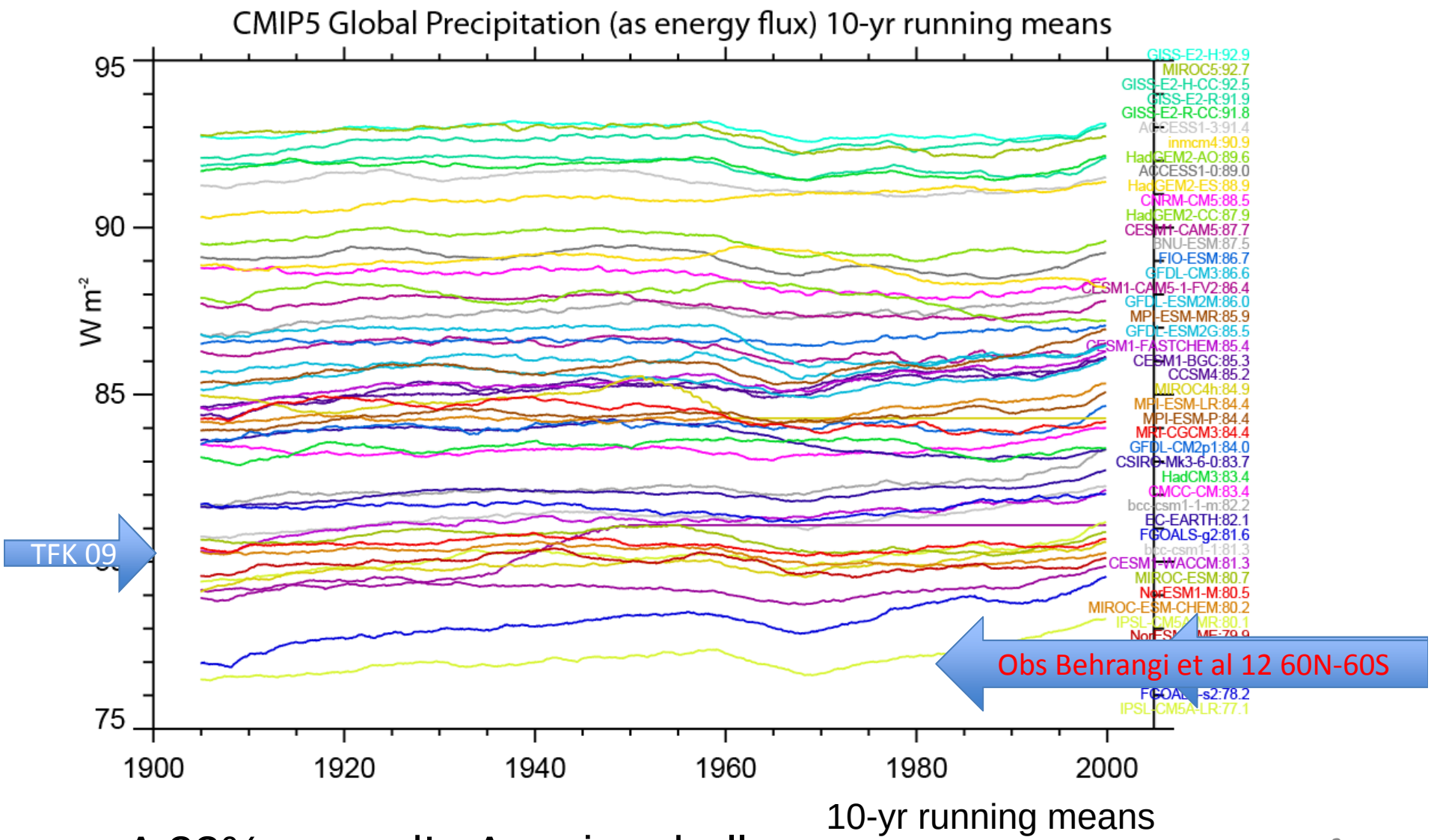
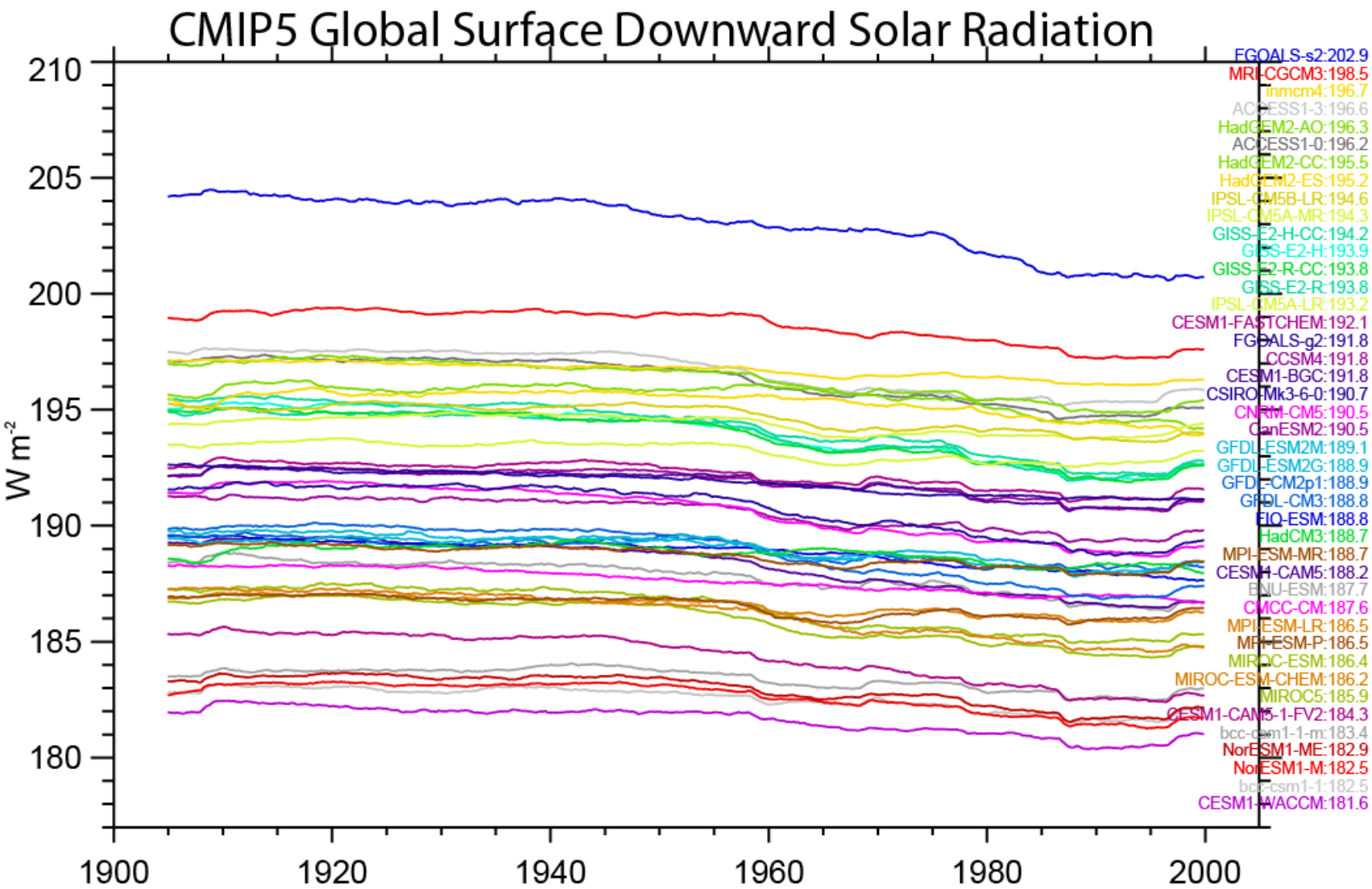
CMIP5 Precipitation



A 22% spread! A major challenge.

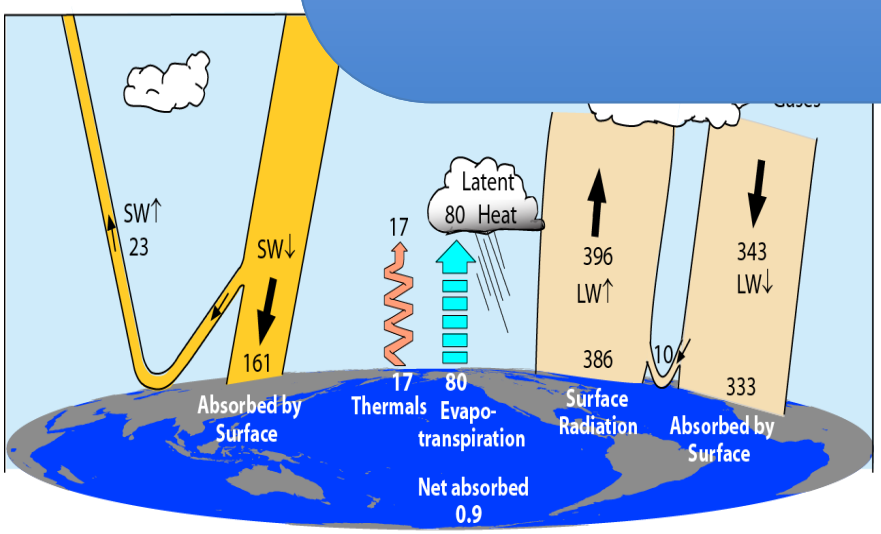
Shortwave down



Gl… …balance

- Relat… …nus preci…
- Majo…
- How …
- Othe…

Do not deal with surface emissivity.
Observations from buoys (WHOI) over oceans suggest the SW is too large.
Problem remains with LW.

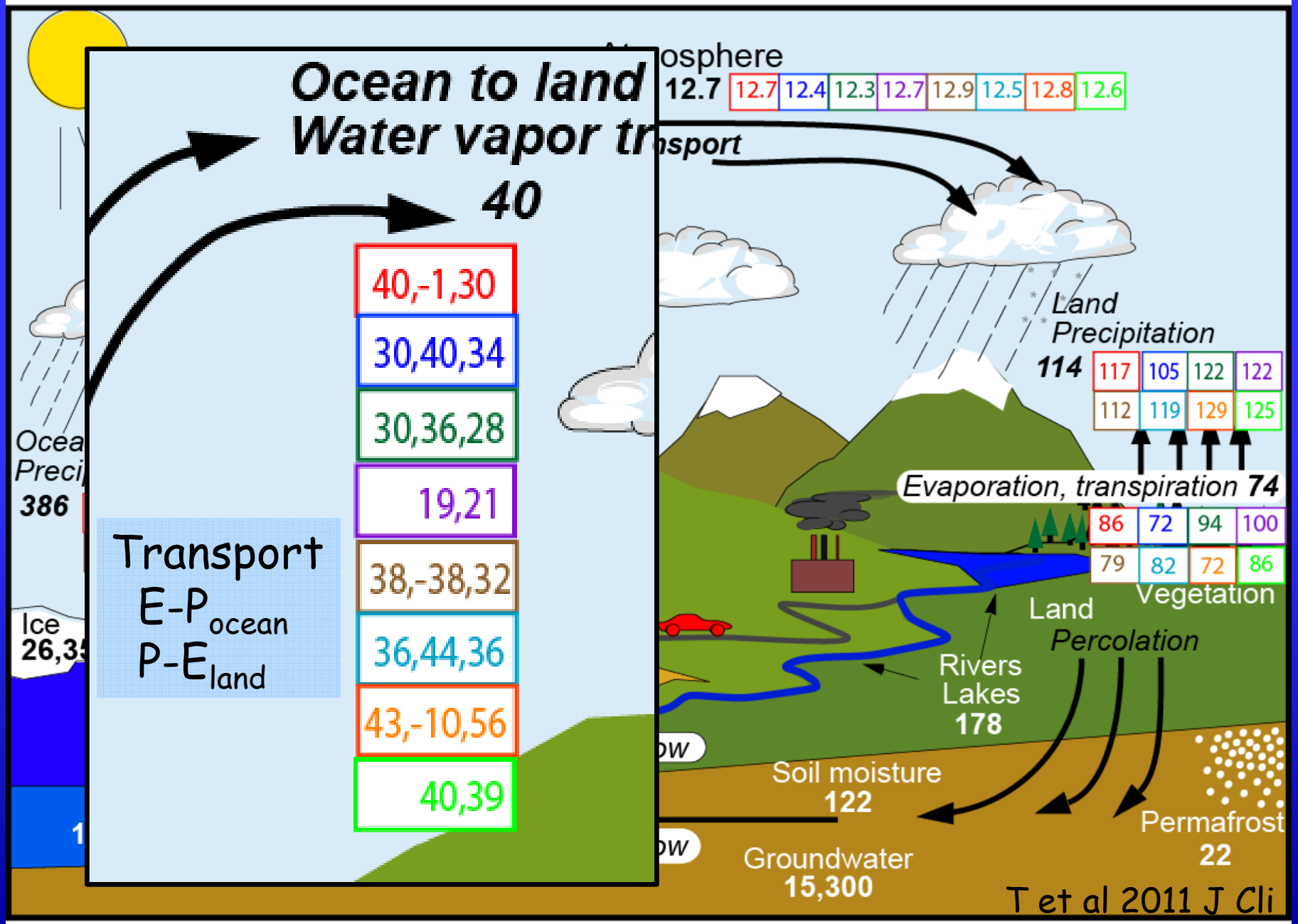


Trenberth, Fasullo and Kiehl 2009

SFC: TFK	SRB (Kato pers. comm 2012)
SW +161	+163
LW -396+333= -63	-398+344=-54
SH -17	(-17)
LH -80 (-76 GPCP)	(-91)
	11

21 W m^{-2} imbalance

Hydrological Cycle: 2002-08



Units: Thousand cubic km for storage, and *thousand cubic km/yr* for exchanges

*1990s

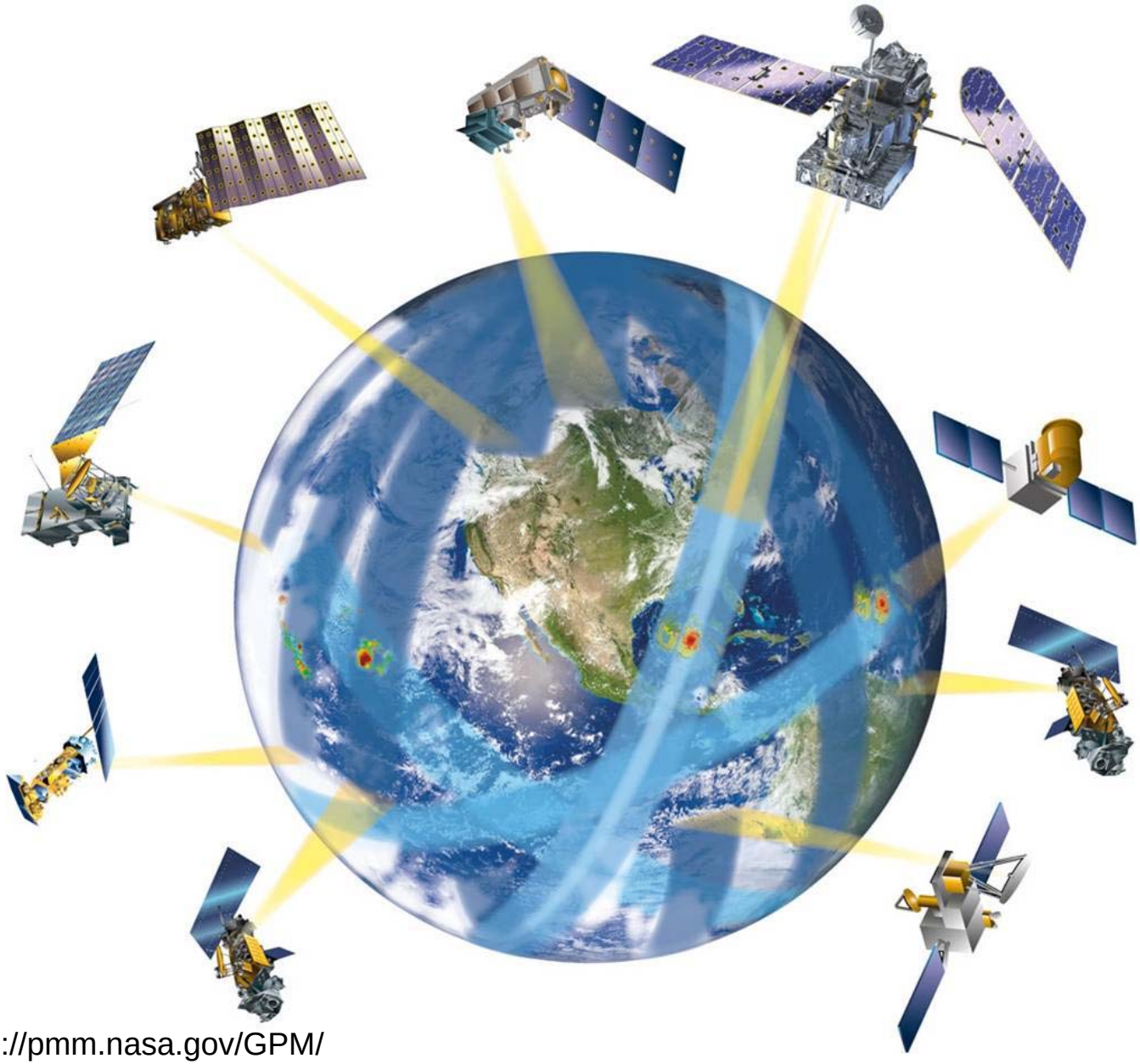
New observations:

Global Precipitation Mission: 3 hr sampling (2014)
Cloudsat, Earthcare: clouds, aerosols (2015)
GRACE: mass
SMOS: soil moisture, salinity
SMAP: soil moisture, freeze/thaw cycle (Nov 2014)
Aquarius: salinity (sfc)
Argo floats: salinity (3D)
Radar; in situ
Flux towers

New products:

Advanced diagnostics
Downscaling, realistic land sfc hydrology,
land use, land management, cryosphere
Data assimilation
Modeling
Synthesis (water balance)
Drought Information System

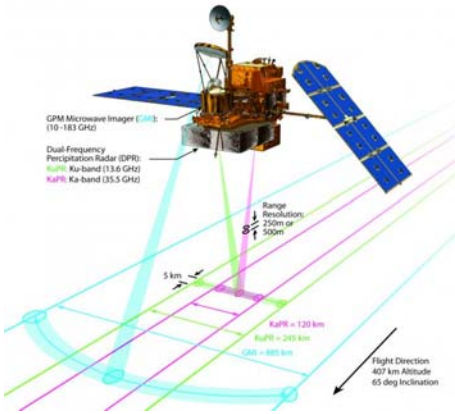
GPM constellation



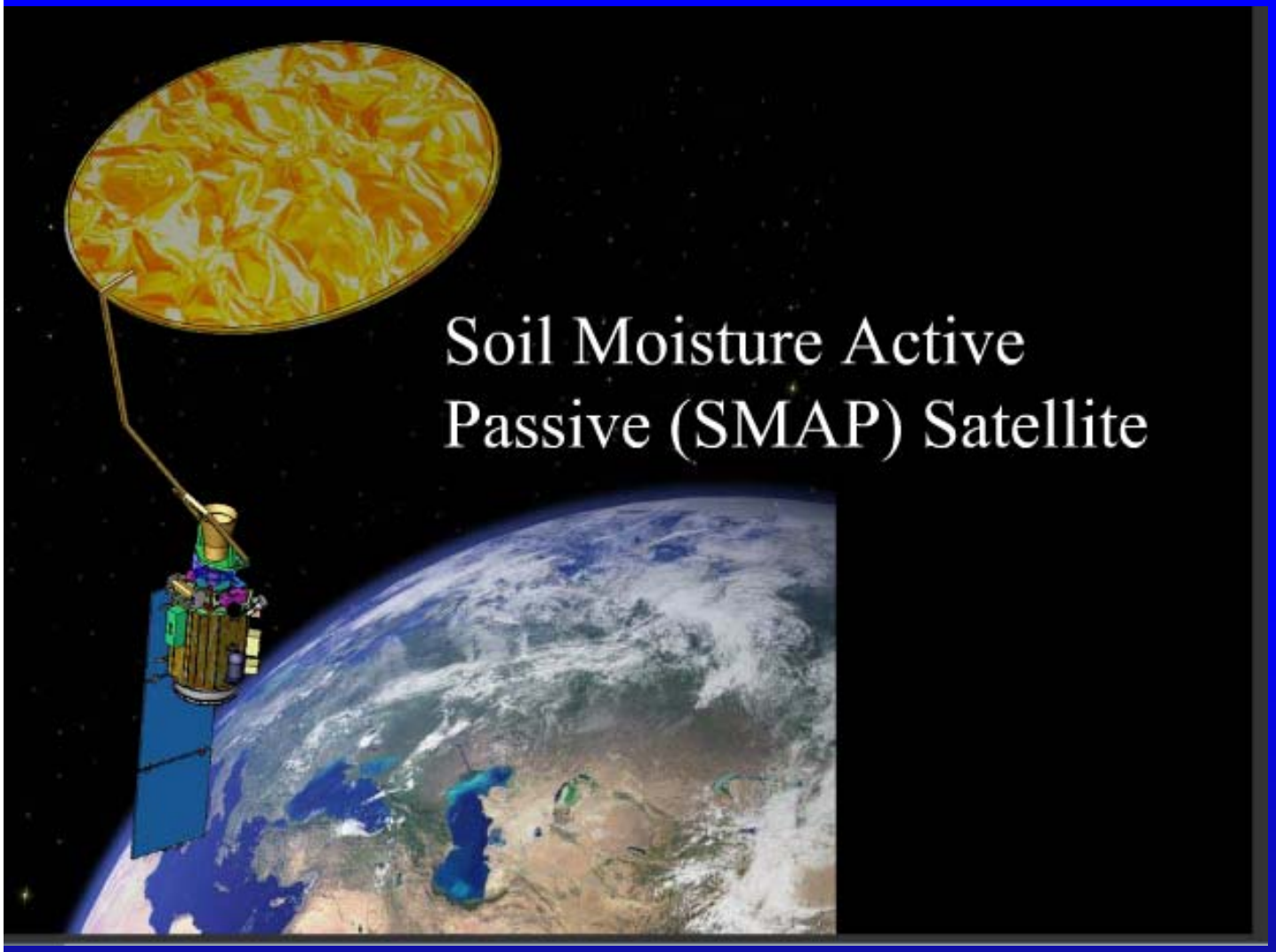
International

Fleet of satellites with radars and microwave radiometers

Mix of active/passive



http://pmm.nasa.gov/GPM/



Launch 2014
L-band microwave radar
6 m reflector
3 day coverage
40 km res for radiometer
3 km res for radar

How should precipitation change as climate changes?

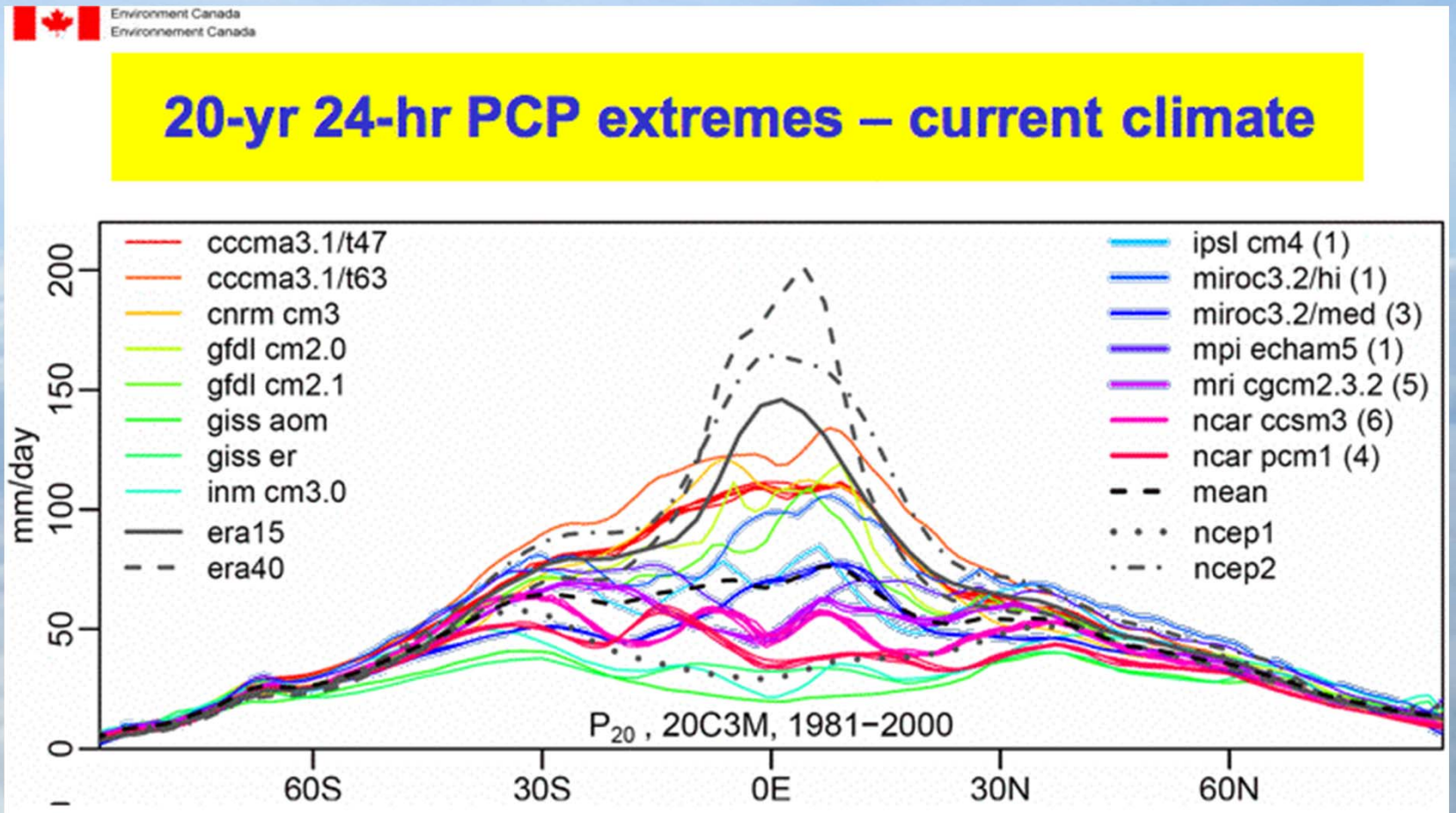
Usually only total **amount** is considered

- But most of the time it does not rain
- The **frequency and duration** (how often)
- The **intensity** (the rate when it does rain)
- The **sequence**
- The **phase**: snow or rain

The intensity and phase affect how much runs off versus how much soaks into the soils.

All models are wrong, some are useful!

Models are demonstrably poor at extremes



Courtesy Francis Zwiers

Precipitation in models:
"all models are wrong, some are useful"

A challenge:

Amount: distribution:
double ITCZ

Frequency: too often

Intensity: too low

Runoff: not correct

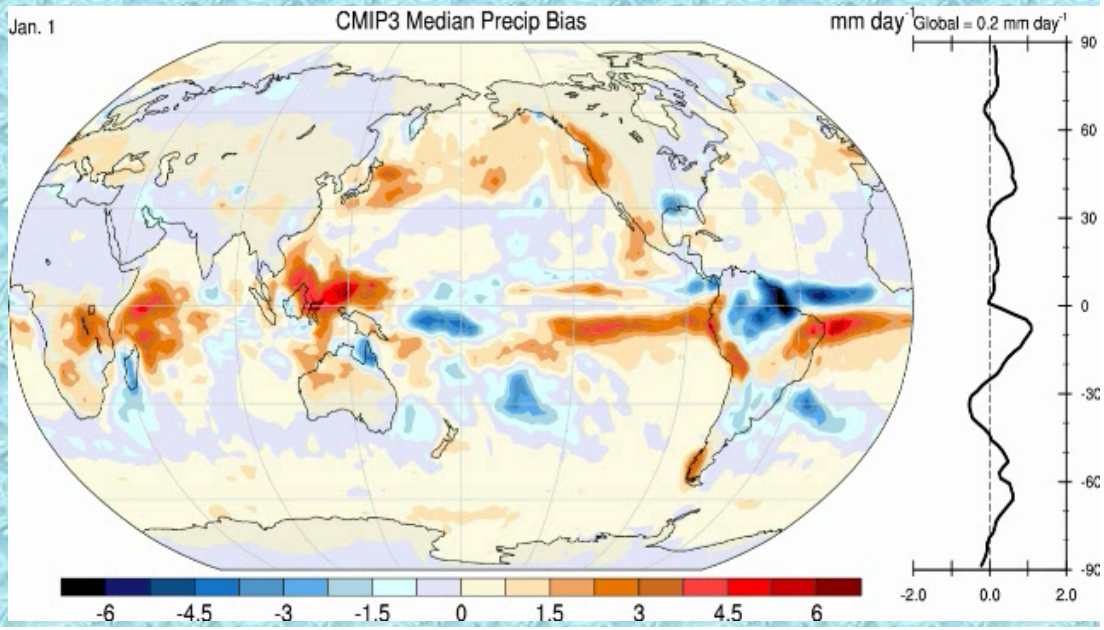
Recycling: too large

Diurnal cycle: poor

Lifetime: too short
(moisture)

Issues:

Tropical transients too weak
- Hurricanes
- MJOs
- Easterly waves
- MCCs



Precipitation characteristics: Extremes

How well are models able to handle extremes and how can we improve their capability?

- **Datasets** at high frequency (e.g., hourly)
- **Character**ize precipitation: pdfs, variability, extremes in obs and models
- Identify important **phenomena** and how well they are represented in models (tropical storms, monsoons, MCCs, MJOs, etc)
- Compare apples with apples (point obs vs grid squares)
- **Confront models** with new observationally-based products
- New **metrics** of performance based on pdfs, extremes;
- Highlight shortcomings and developmental needs: focus field programs, process studies, numerical experimentation, and model development.

GEWEX Science Questions

How can we better understand and predict variations and changes in precipitation?

- use and development of expected improved **datasets** on: precipitation and soil moisture from ongoing and planned satellite missions, as well from in-situ observations;
- evaluation and **analysis** into various products;
- document the mean, variability, patterns, extremes and full probability density functions,
- **confront models** in new ways;
- improve understanding of atmospheric and land surface **processes** and their **modeling** that improve simulations of precipitation;
- employ new techniques of data assimilation and forecasts that improve predictions of the hydrological cycle.