

# Sun-Climate Observations – the Future.

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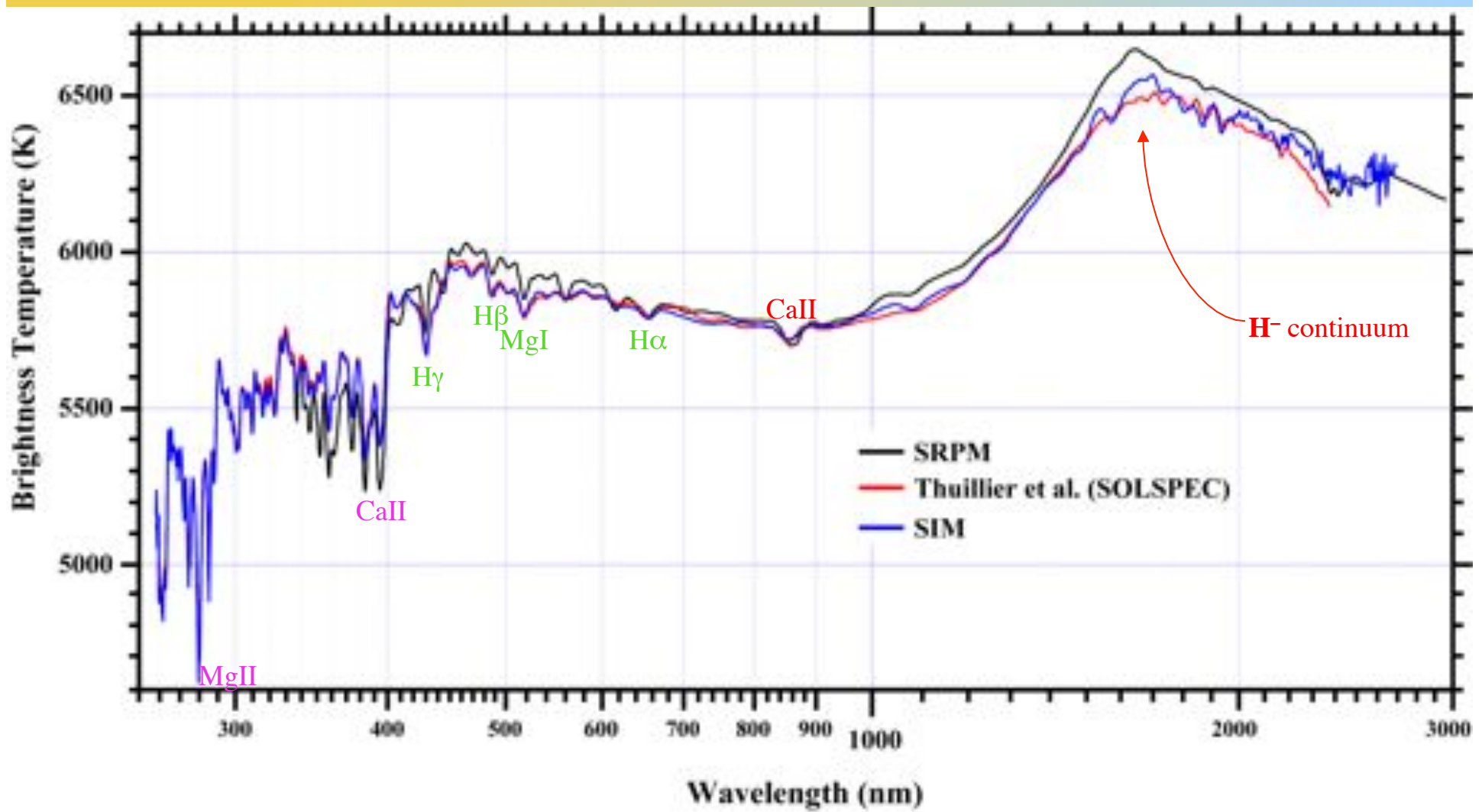
“Greater effort is needed to resolve the interactions at the atmosphere’s boundaries (oceans, ice, and land surface and vegetation), enable an improved understanding of clouds and cloud feedbacks, and characterize the role of aerosols.” –NAS

“Time is that quality of nature which keeps events from happening all at once. Lately it doesn't seem to be working.” – Anonymous

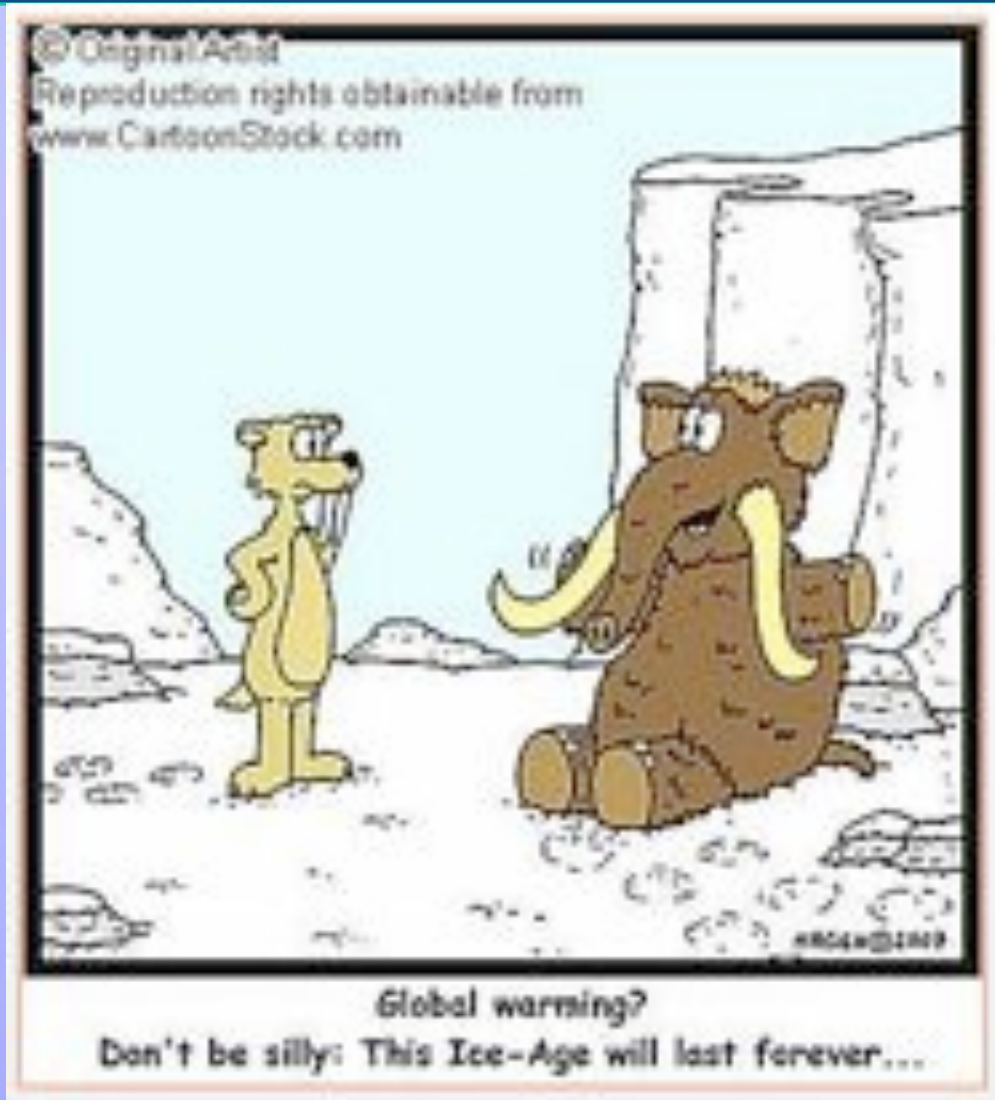
- **Earth Observations Now:** RoboNets, GPS Nav, Formations, Lidar/Radar
- **Earth Observations Later:** SensorNets, Localized Services, MicroSats,...surprises
- **Remote Sensing Now:** multispectral 1D, ATBDs, Open Source 3D RT
- **Remote Sensing Later:** multi-instrument 3D, ATBwiki, Open Source 4D RT
- **Earth System Models Now:** Global Scenarios, photochemistry
- **Earth System Models Later:** Regional/Local Scenarios, photobiology



*New climate data is just beginning to be understood.*



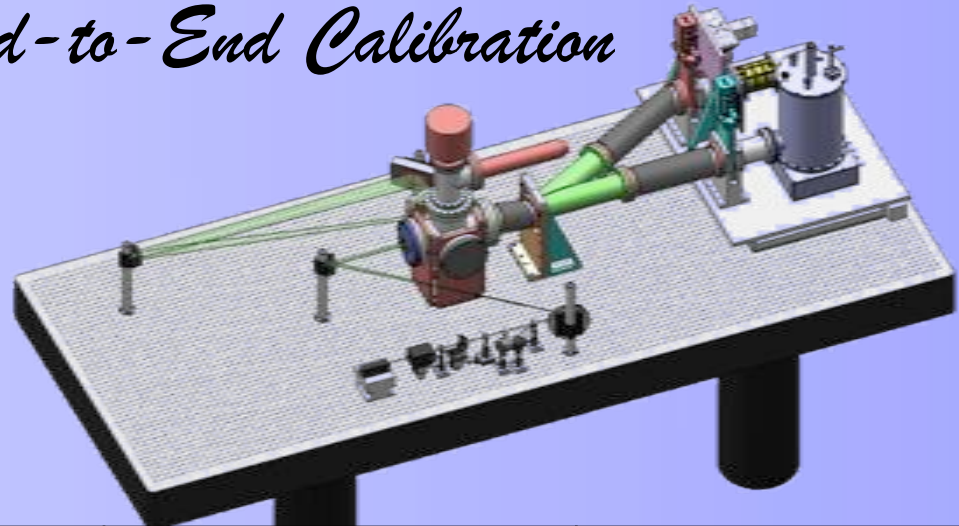
# What *some* have said about the Future.



## •New *LASP* Facility for End-to-End Calibration

- compare each TSI instrument against NIST-calibrated cryogenic radiometer in the TSI Radiometer Facility (TRF)

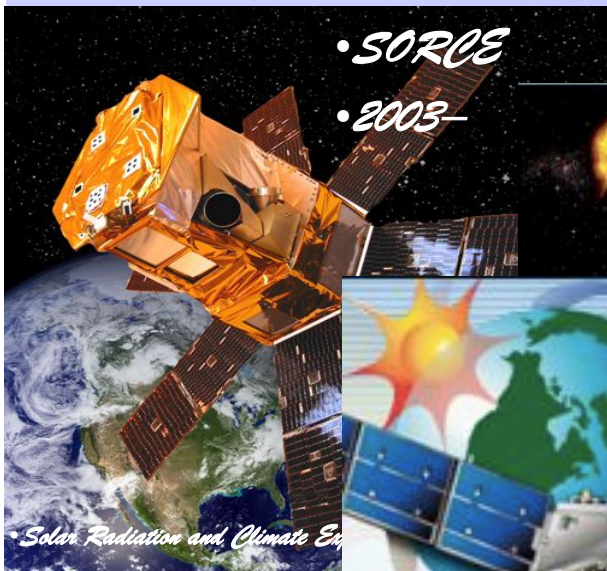
- Glory TSI agrees to 200 ppm
- PICARD PMO instrument at TRF late summer



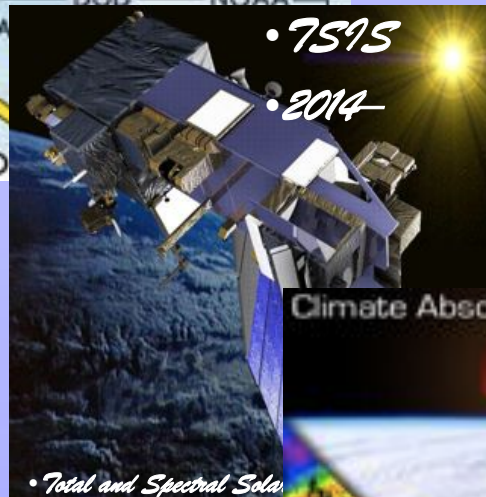
Facility	SI Reference	Operating Conditions	Comments
Table Mountain	none	<ul style="list-style-type: none"> <li>•vacuum</li> <li>•solar viewing</li> <li>•window transmission</li> <li>•circumsolar scatter</li> </ul>	no link to SI and scatter effects limit usefulness of comparison
World Radiation Reference (WRR)	linked to NPL (with high uncertainties)	<ul style="list-style-type: none"> <li>•solar viewing</li> <li>•air operations</li> <li>•circumsolar scatter</li> </ul>	air operations and scatter limit absolute accuracy
NRL Cryo Radiometer	NIST calibrated cryo radiometer	<ul style="list-style-type: none"> <li>•vacuum</li> <li>•solar power level</li> </ul>	not built
TSI Radiometer Facility (TRF)	NIST calibrated cryo radiometer	<ul style="list-style-type: none"> <li>•vacuum</li> <li>•solar power level</li> </ul>	proven on Glory/TIM



# Climate Missions : Research to Operations

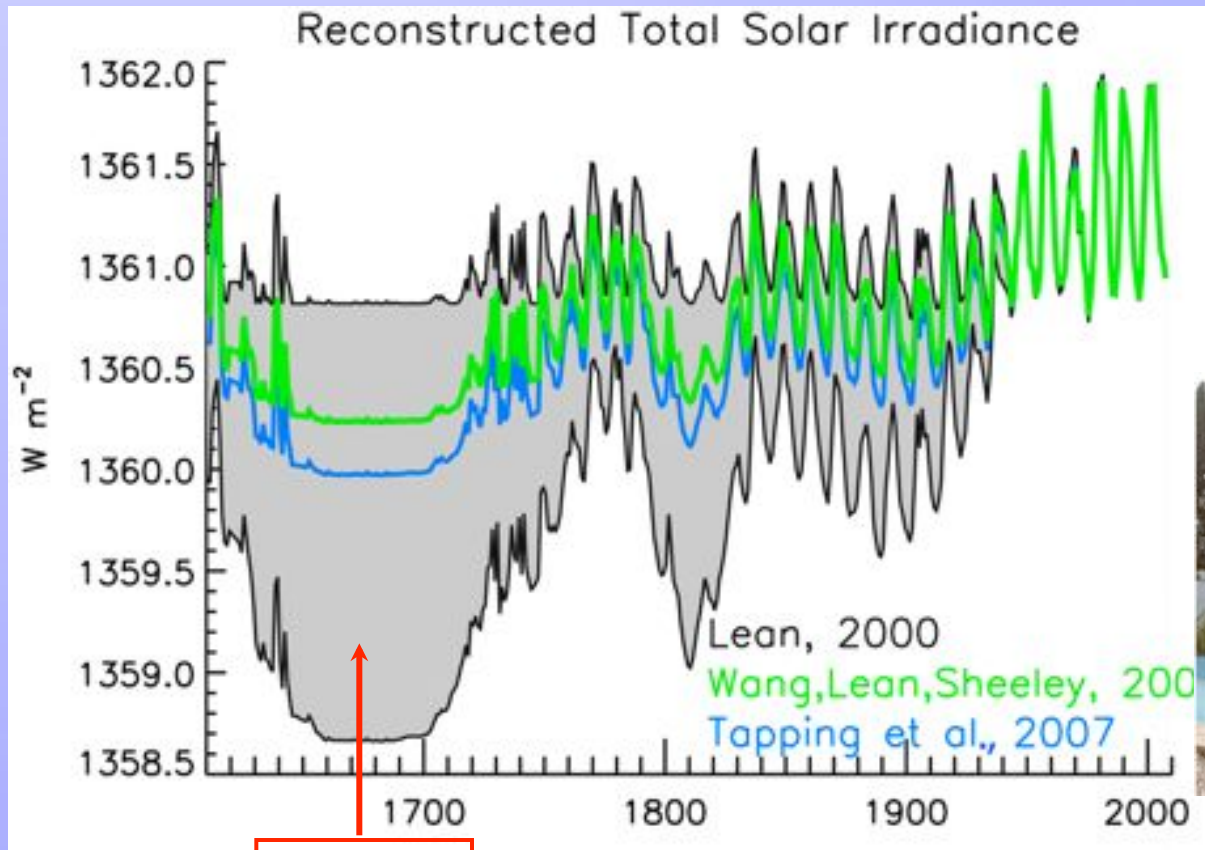


- SORCE (2003-): TIM, SIM, SOLSTICE, XPS
- Glory (2010): APS, TIM
- NPP (2010): VIRRS, CERES, +3
- TSIS (2014): TIM, SIM
- CLARREO: AASI, CORSAIR, hyperspec
- .....



## •Long-Term Reconstructions

- Improved solar models will enable improved reconstruction of the irradiance back to the Maunder Minimum



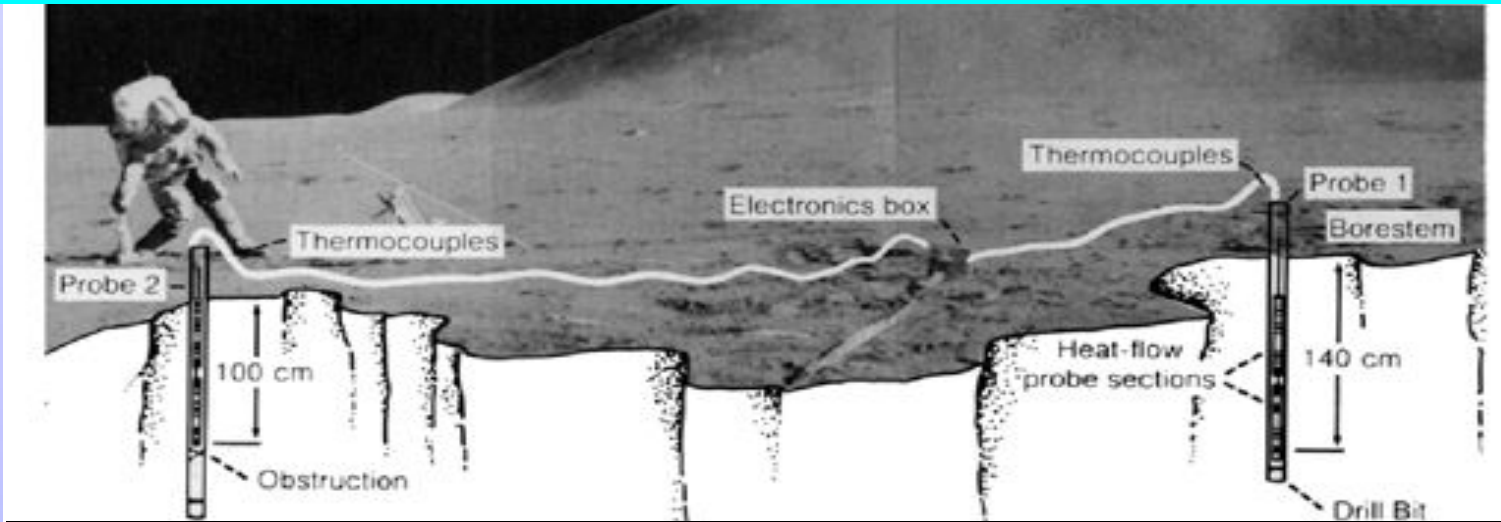
- Current Estimate for
- Maunder Minimum
- 400-year Variability
- 0.07% = 1 W/m<sup>2</sup>



- Maunder
- Minimum

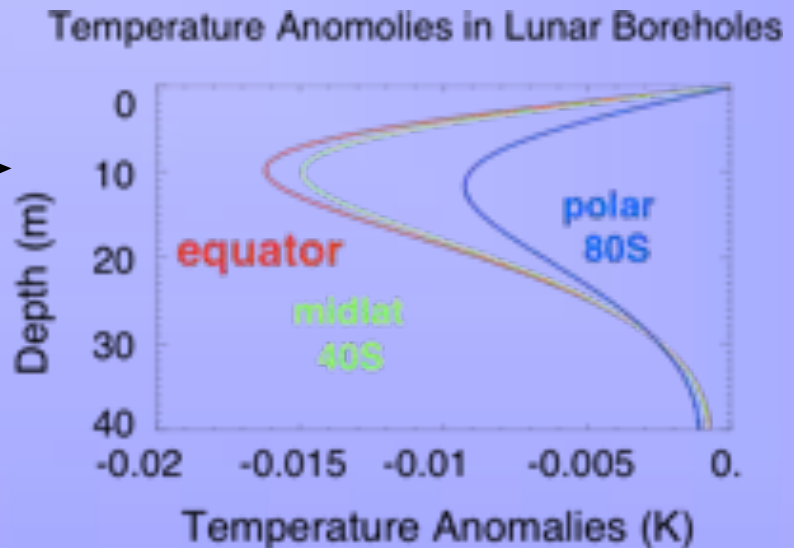


# •Apollo Heat Flow Experiments (HFEs)



•Heat Flow Experiments (HFEs) from Apollo 15 & 17 show very small thermal diffusivity of lunar regolith  $\approx 10^{-8} \text{m}^2/\text{s}$ , 100 X smaller than that of Earth's crust.

•Temperature anomalies as response to two scenarios of reconstructed TSI at the equator, mid-latitude and near south pole.



# What *others* have said about the Future.

"The biggest lesson in business is that it's going to be a rollercoaster."

-- Marc Andersson, Netscape founder

"Predictability: Does the Flap of a Butterfly's Wings in Brazil set off a Tornado in Texas?"

-- Ed Lorenz, 1972 AAAS Meeting

"It's rough to make predictions, especially about the future."

-- Casey Stengel, Yogi Berra, Niels Bohr.

"There are two classes of people who tell what is going to happen in the future: Those who don't know, and those who don't know they don't know."

-- John Kenneth Galbraith

"It may happen that small differences in the initial condition produce very great ones in the final phenomena. A small error in the former will produce an enormous error in the latter. **Prediction becomes impossible**, and we have the fortuitous phenomenon."

-- Poincaré

"if at one time, we knew the positions and speeds of all the particles in the universe, then we could calculate their behaviour at any other time, in the past or future."

-- Laplace, as paraphrased by Stephen Hawking





## Add your predicted upcoming discoveries here →

- aerosol - cloud - *chemistry*
- New active sensors see *inside* clouds and ice sheets
- Climate Models compute *radiances* for validation
- IPCC assesses *regional* change
- Changes seen on Moon and Mars clarify Earth paleoclimate
- Predictability of Solar Cycle and ENSO clarified
- ...



# And now ...

