Building of a climatology of IASI radiance spectra. First results at global and regional scale

Thierry PHULPIN and Sébastien GAUGAIN

7 February 2013

3rd IASI International Conference
Hyères, France

Acknowlegments : M. Ringer, F. Chauvin and S. Planton

OUTLINE

- IASI for Climate
- Global and regional climatology
- Simulation with 4A and Tigr2000, sensitivity studies
- Indicators
  - for OLR and LW surface radiation
  - SST (at night)
  - For ECV : Surface Temperature, atmospheric temperature (LT, UP, LS, HS/M), humidity, ozone and others GHG
  - Others : reflected Sun radiation, spectral emissivity

- Year to year comparison (including inverse ECV)
- Monthly variations
- Conclusion on the products
- Advantages of IASI L1C
- Next steps

  Assessment of projections (CMIP5) and regional climate models

  More precise inversions

Why using IASI for Climate studies

- Very stable
- Very well calibrated → a reference for re-calibration of infrared sensors (WMO's GSICS)
- 15 years of data and more with the continuation with IASI-NG
- Very large information content on atmospheric essential climate variables (ECVs)

In summary IASI is well sized to deliver FCDR and TCDR for Climate monitoring (trends and attribution).

It can also be valuable in study of processes, or seasonal forecast.

Starting now a global climatology

- Already 5 years of data
- Representing 2MB/s, 170GB/d, 63 TB/y (B=byte)
- Implies monthly computation and archiving.

L1C > less frequent reprocessing than L2
Explore the wealth of spectral content over the whole spectra
Promising previous work (Harries (2003), T. Slingo, ..) etc.

- Why radiance spectra?

- Which scale ? Global scale (like altimetry). Global change at planet scale
Regions (ENSO34 and W Pacific, latitude belts)

- Which time period? Monthly values. Seasonal if pertinent. Year to year variations

- Which various conditions? All, land/sea, day/night, cloud free (CF=0), overcast

Improvement still possible, suggestions welcome

DATA USED IN CLIMATOLOGY

- IASI Level 1C spectra archived at Ether center
- Period of time : March 10 to December 12
  June 10 to last month
- Includes AVHRR cloud fraction in IASI pixels

Cloud mask count	1,36E+07	
Average cloud mask	69,2419	
Clear pixels count	1,49E+06	89,06
Cloudy (>=95%) pixels count	7,25E+06	
Pixels count	1,36E+07	
Cloud mask standard deviation	39,5504	

Huge number of pixels (night only!)
Mean cloud fraction ≠ ratio of cloud contaminated pixels

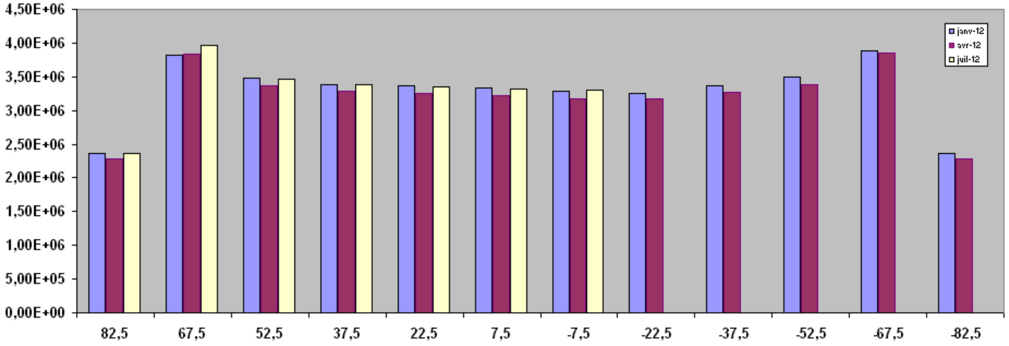
Ch.	mean rad	Clear mean	Cloud mean	All rms	Clear rms	Cloud rms	all sk.	Clear sk.	Cloud sk.	Kurt.	Clear kurt.	Cloud kurt.	all_Tb	clear_Tb	cloud_Tb
1	4,273E-04	4,051E-04	4,400E-04	5,81E-05	3,30E-05	6,39E-05	0,953	1,898	0,591	3,152	7,820	2,382	214,42	211,84	215,87
2	4,309E-04	4,073E-04	4,453E-04	6,25E-05	3,45E-05	6,88E-05	0,952	2,086	0,566	3,020	8,212	2,231	214,87	212,13	216,48
3	4,430E-04	4,256E-04	4,583E-04	7,09E-05	3,47E-05	7,87E-05	0,749	2,116	0,408	2,872	9,167	2,143	216,25	214,28	217,96
4	4,827E-04	4,849E-04	4,960E-04	8,57E-05	3,47E-05	9,42E-05	0,072	0,863	-0,042	2,601	9,829	2,179	220,63	220,87	222,04
5	4,823E-04	4,843E-04	4,958E-04	8,59E-05	3,49E-05	9,45E-05	0,090	0,899	-0,027	2,609	9,824	2,179	220,61	220,82	222,04
6	4,425E-04	4,240E-04	4,580E-04	7,03E-05	3,50E-05	7,80E-05	0,794	2,149	0,440	2,887	9,117	2,135	216,28	214,17	218,00
7	4,249E-04	3,976E-04	4,401E-04	6,40E-05	3,67E-05	7,00E-05	0,968	2,019	0,579	2,983	7,701	2,214	214,31	211,12	216,04

skewness kurtosis

Global statistics or regional

VALIDITY OF CLIMATOLOGY

- Averaging over all angles
- Homogeneity of spectral sampling



Satisfactory sampling
(even if weight of poles slightly reduced)

- Statistical distribution

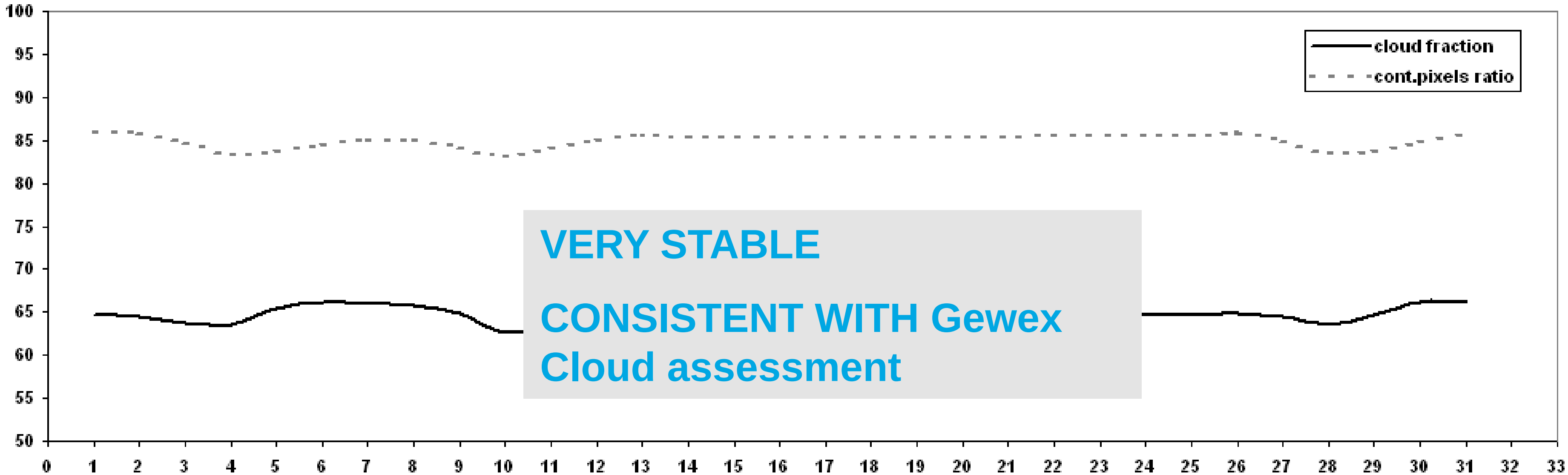
Analysis still to be finalized

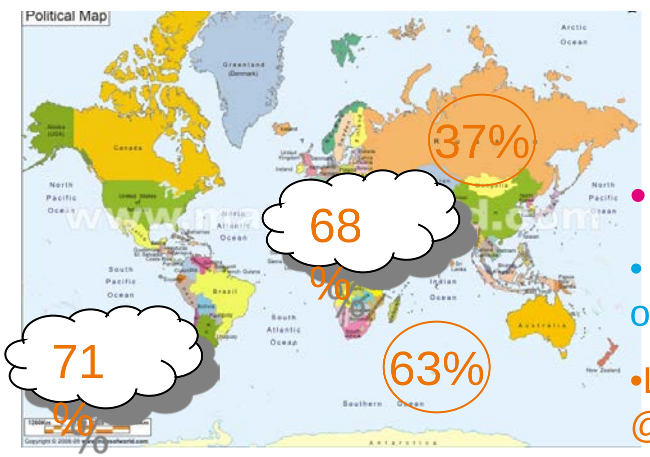
- Cloud fraction

Quality of climatology of clear pixels depends on cloud fraction accuracy.

cnes

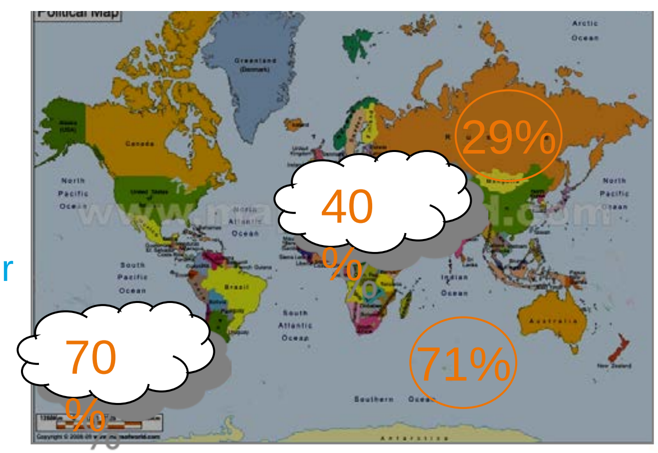
Cloudiness



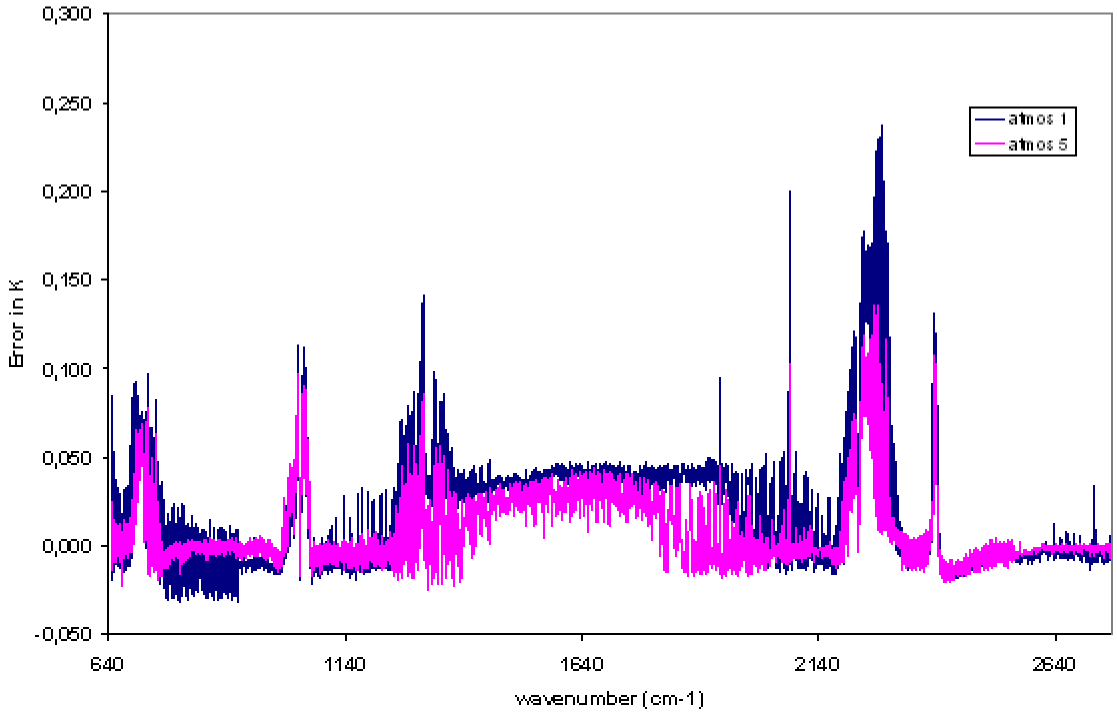


More pixels over land daytime

- More cloudy over ocean
- Cloud fraction stable over ocean
- Less cloudy over land @9:30 AM



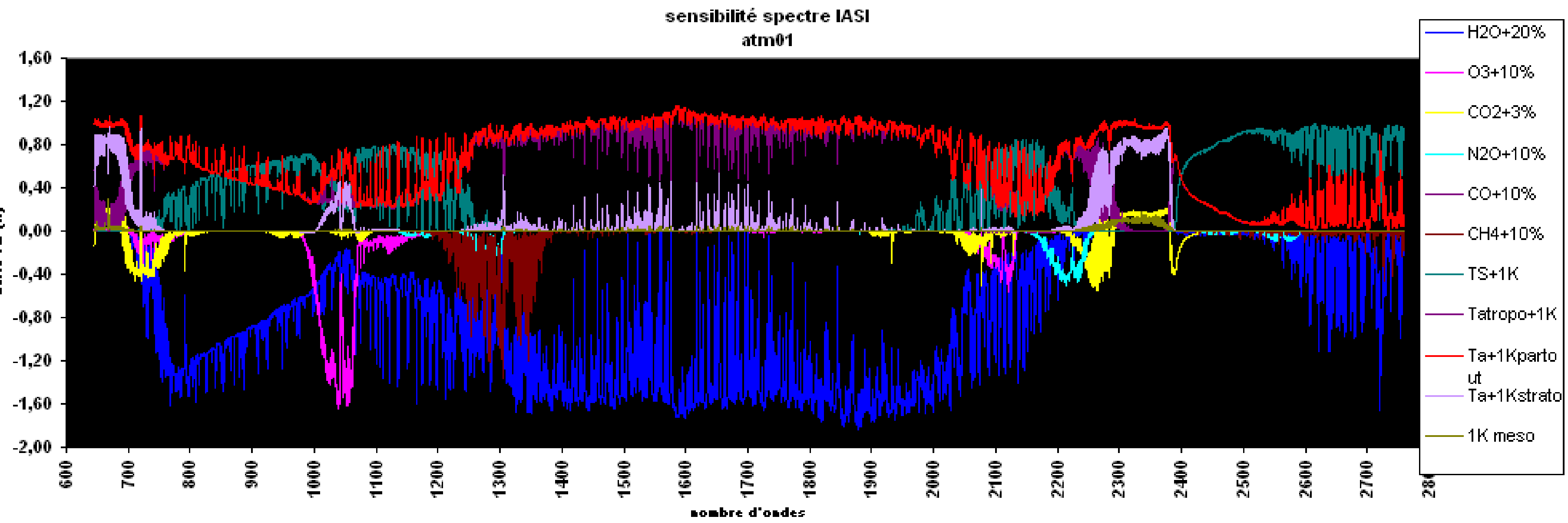
SIMULATION OF SENSITIVITY



Averaged over all view angles spectra ≈ spectra under 30°

Performed with 4AOP-2012 with Tigr2000 mean atmospheres

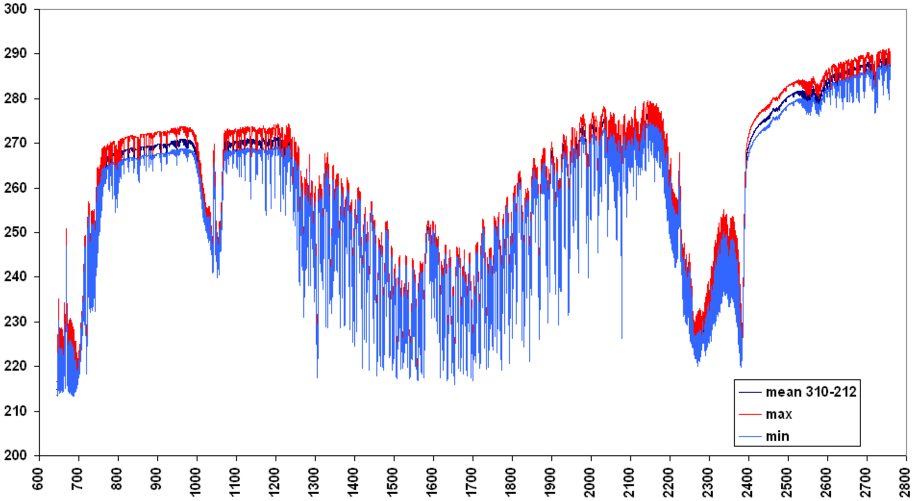
SIMULATION OF SENSITIVITY (2)



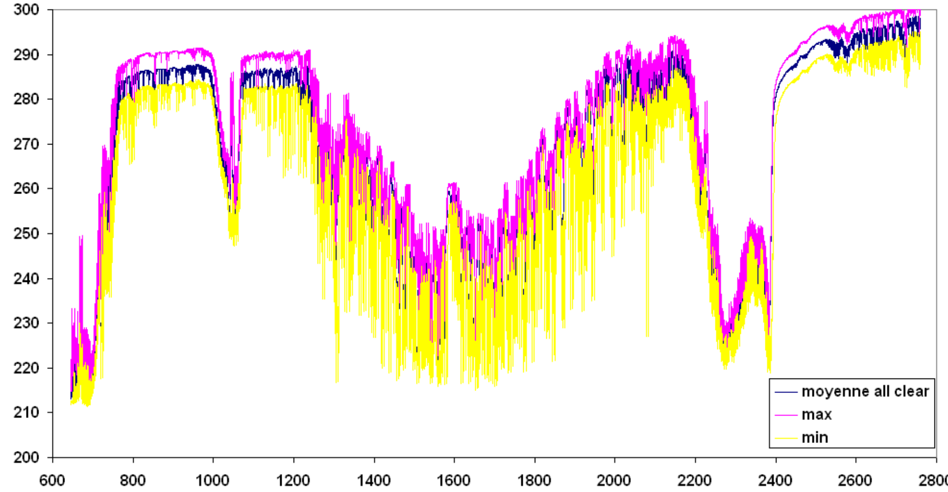
- Information in micro channels, in the slope, in the whole spectrum
- Surface Temperature T_s (incl. clouds), atmospheric temperature (LT, HT, LS, HS/MS), mean humidity, O_3, N_2O, CO, CH_4, etc.
- Jacobians from the more reprsentative to inverse small variations
  - Focus on year to year global variations

Global statistics

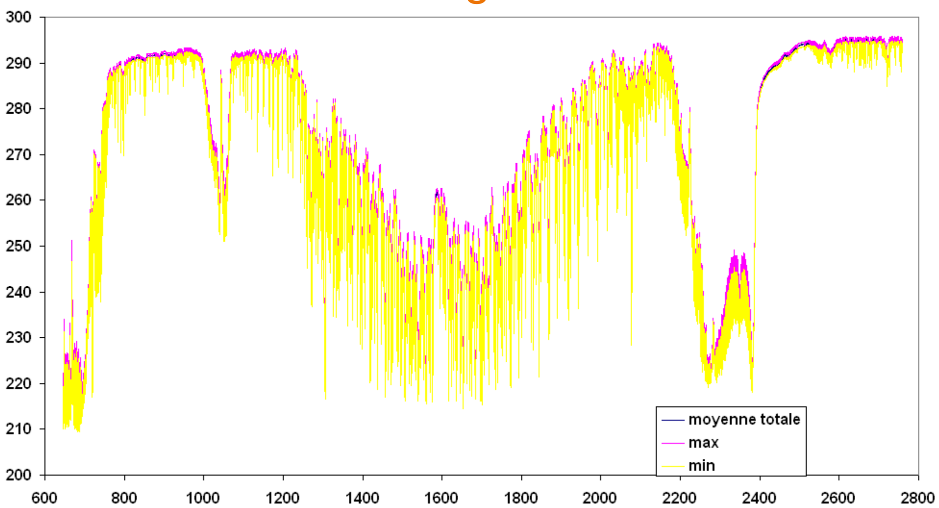
All- All



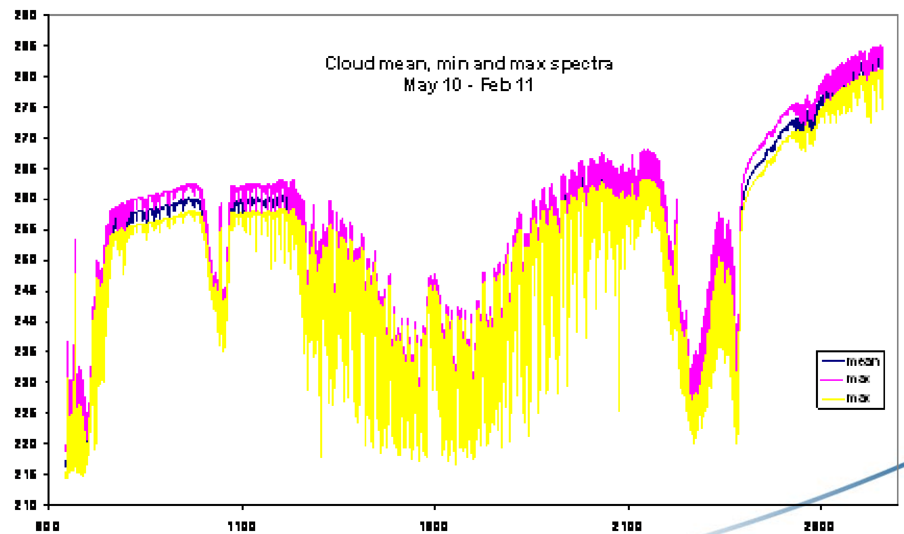
All- cloud free Ts=293.7 K



Sea at Night



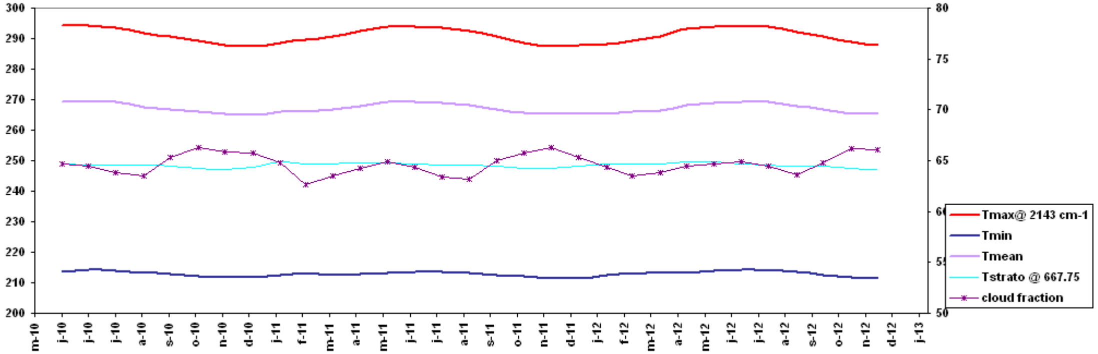
All - Overcast (F> 0.95)



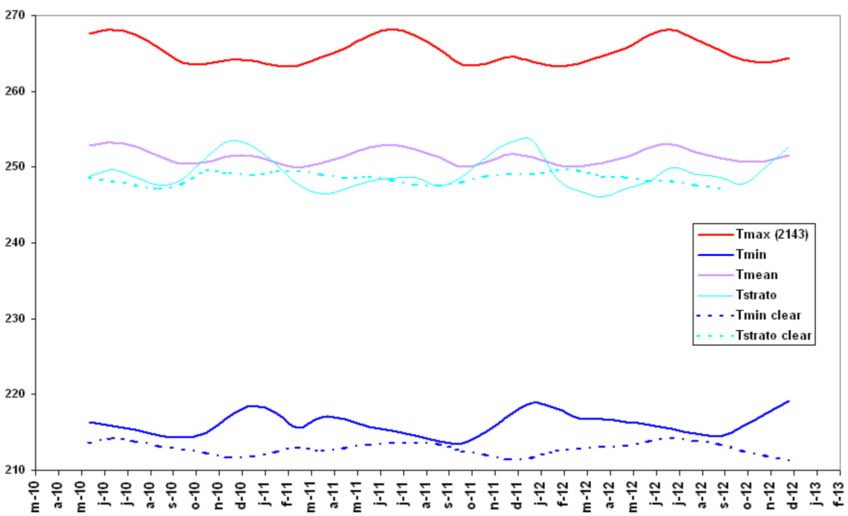
Climate Indicators

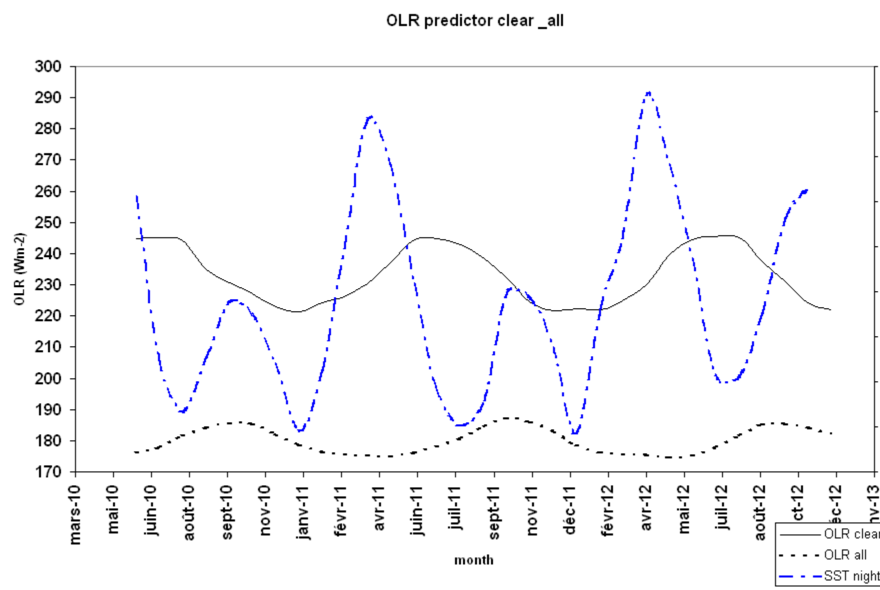
All Cloud free pixels cover

Sea Cloud free pixels at night

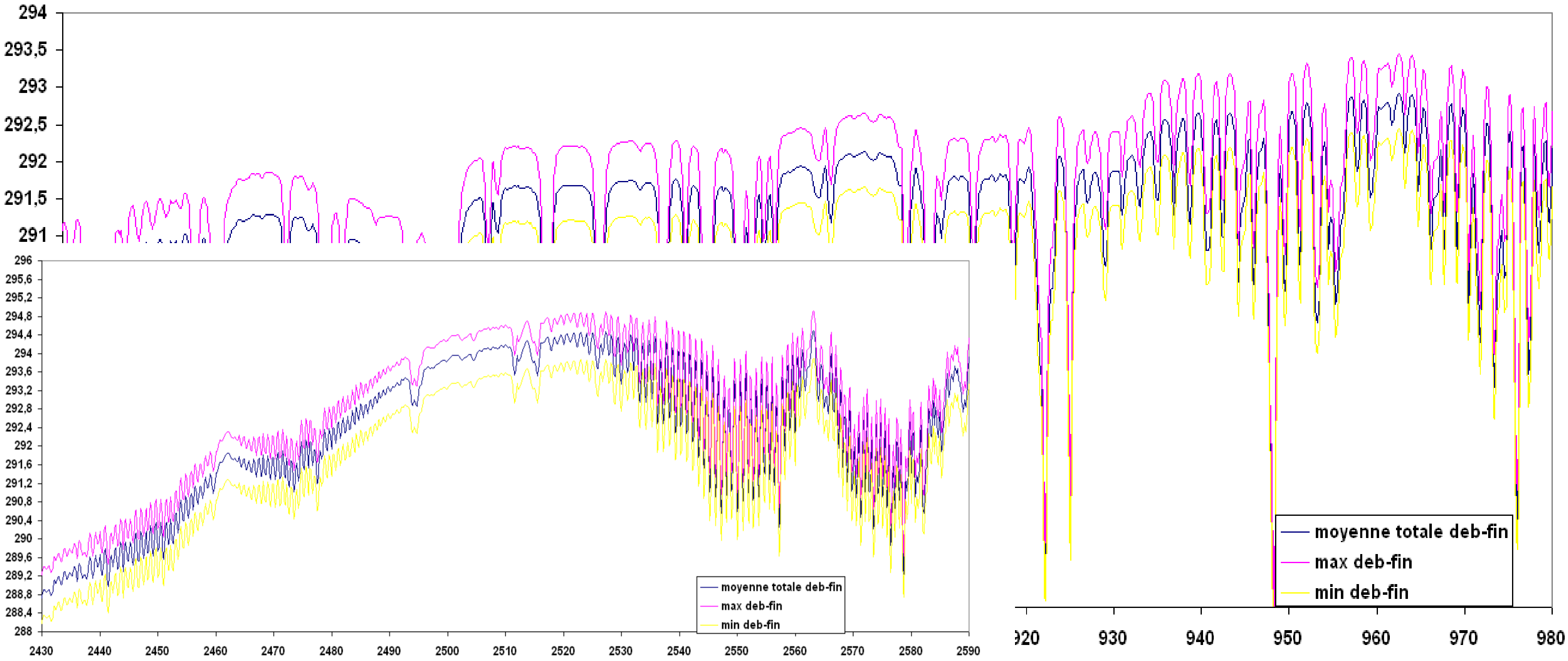


Overcast pixels





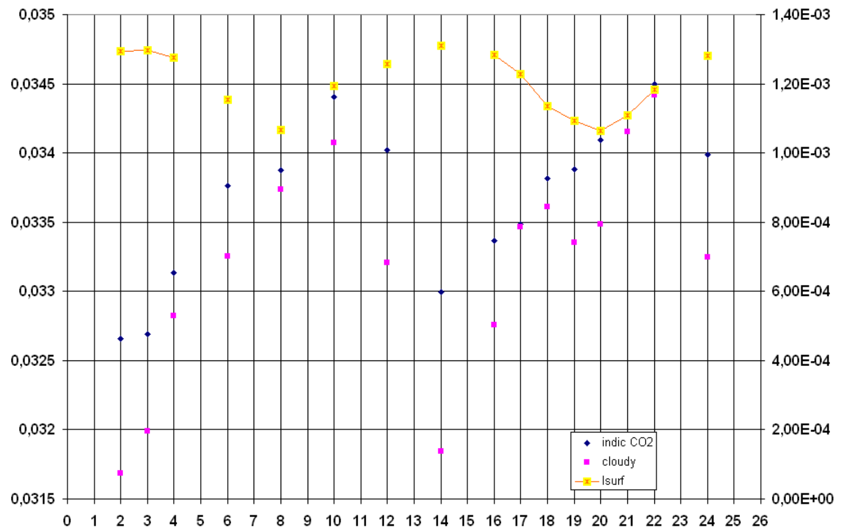
Other quantities to monitor



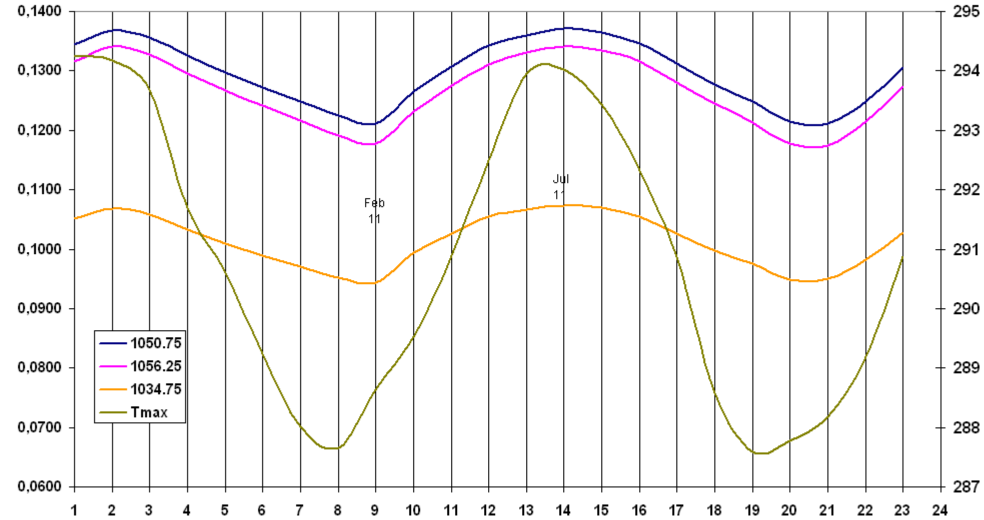
Trace gases at climate scale

Indicator based on RD or BTD : $(I_l-I_w)/I_w$, or in TB

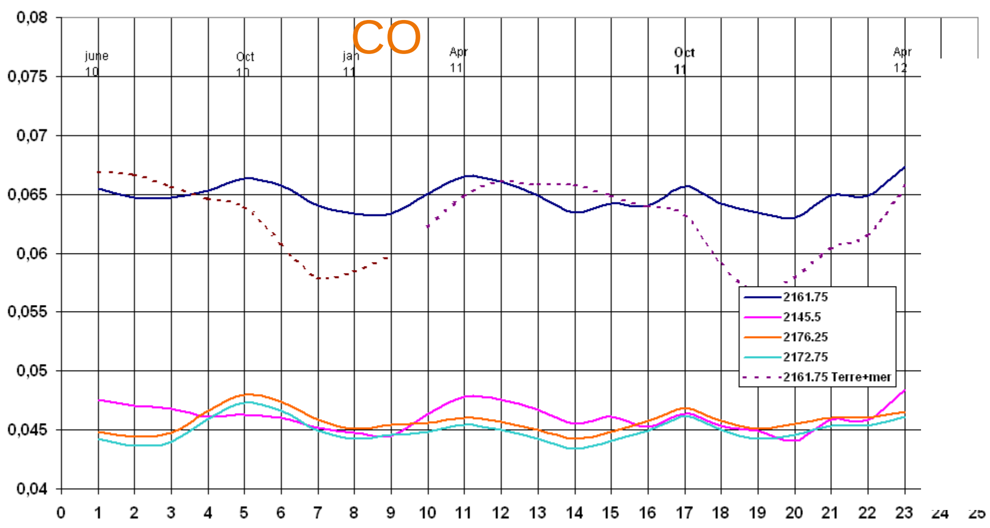
CO_2



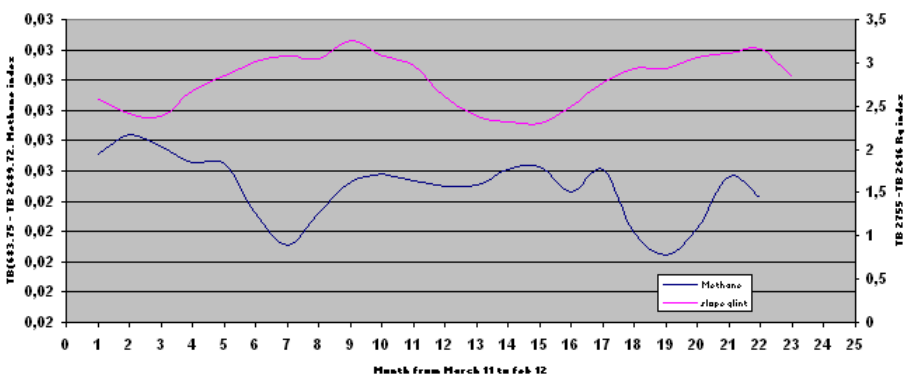
O_3



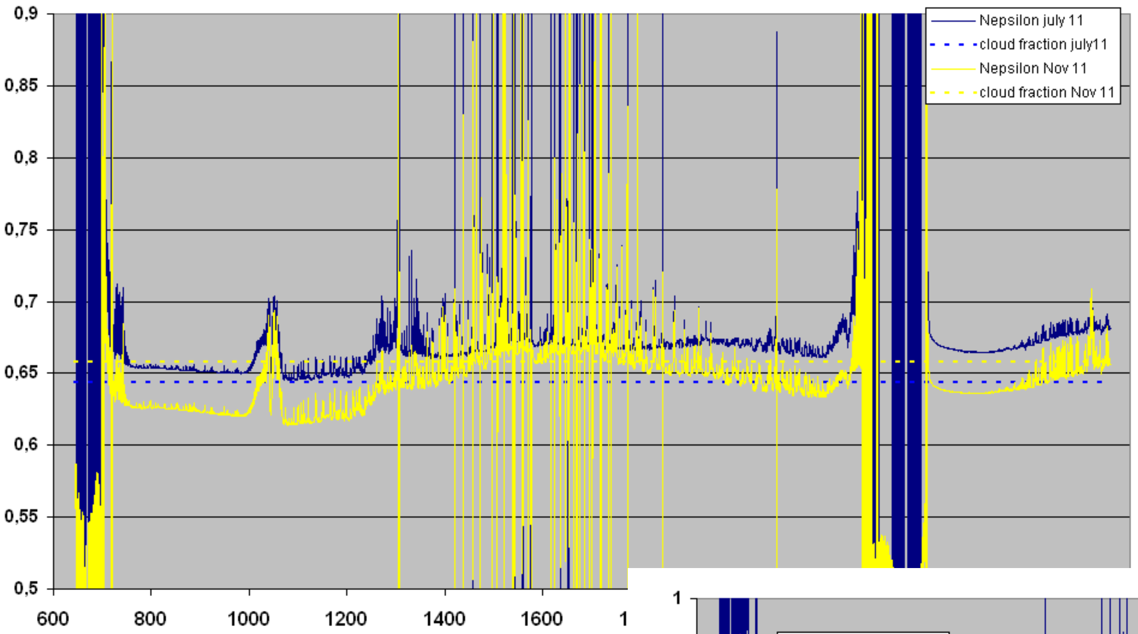
CO



CH_4



Cloud spectral emissivities



Effective cloud cover

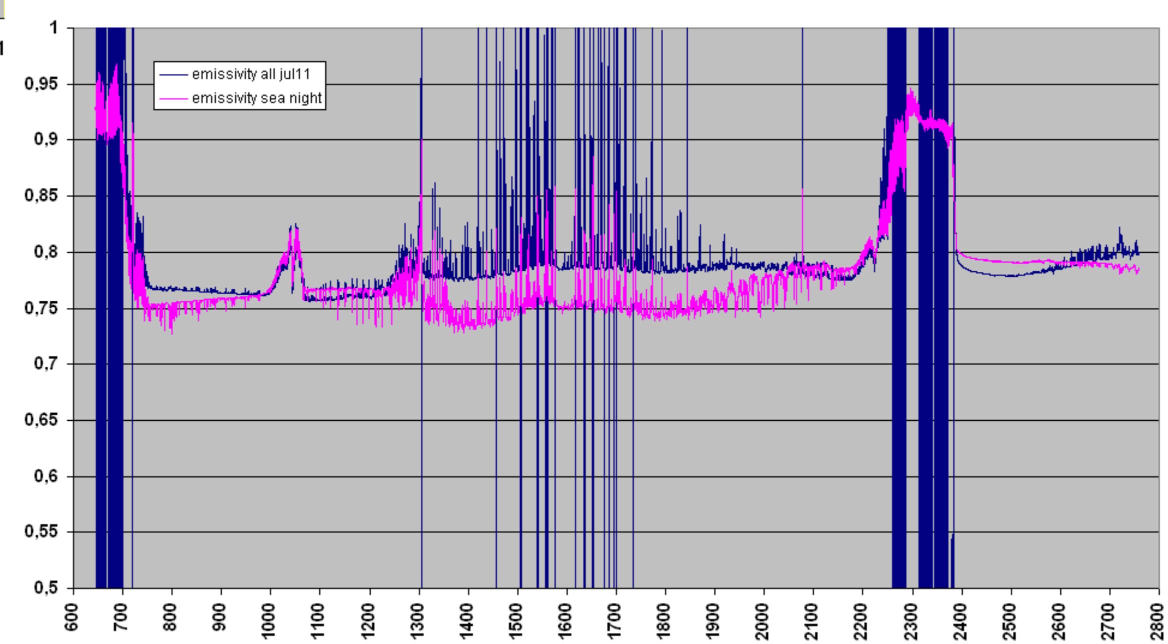
$\alpha = (I_{cl} - I_{all})/(I_{cl} - I_{cloud})$

$\alpha \sim$ cloud fraction f

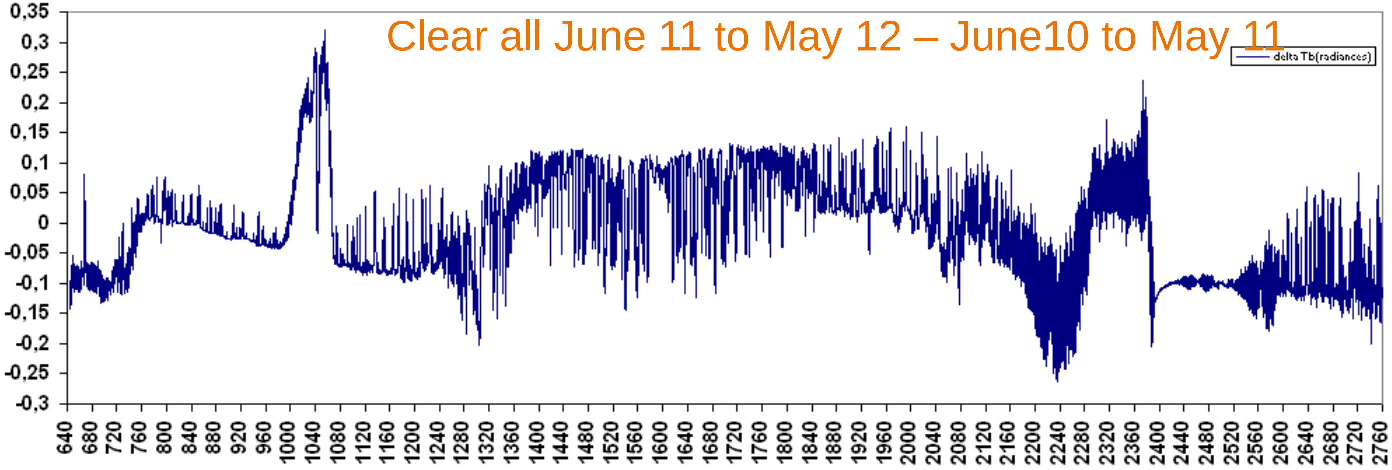
Emissivity :

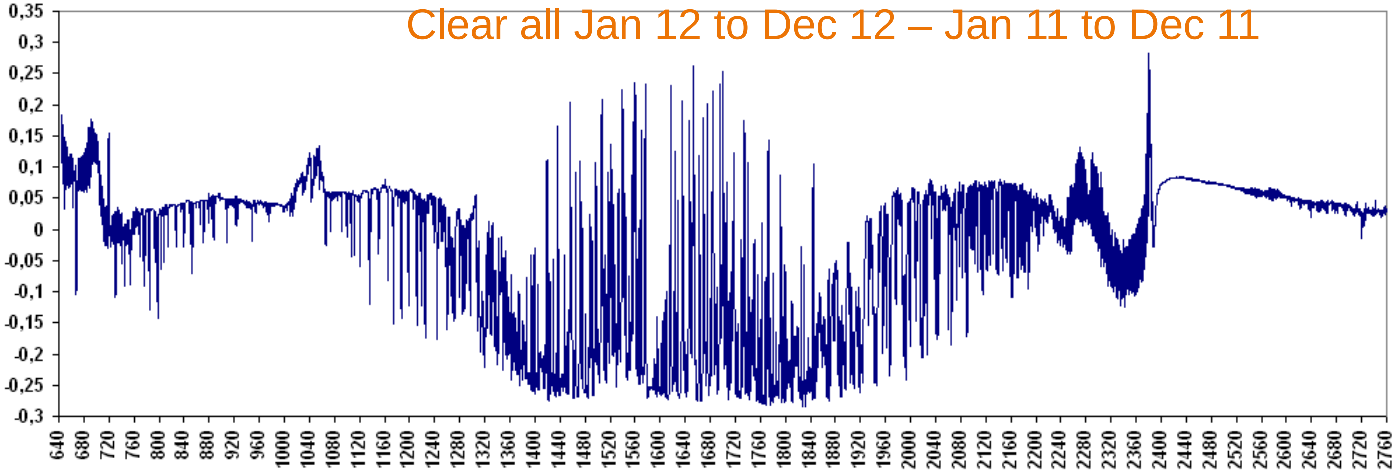
$\varepsilon = \alpha / N$

Middle clouds (including partly covering and semi transparents) are roughly grey bodies.



Year to year variations

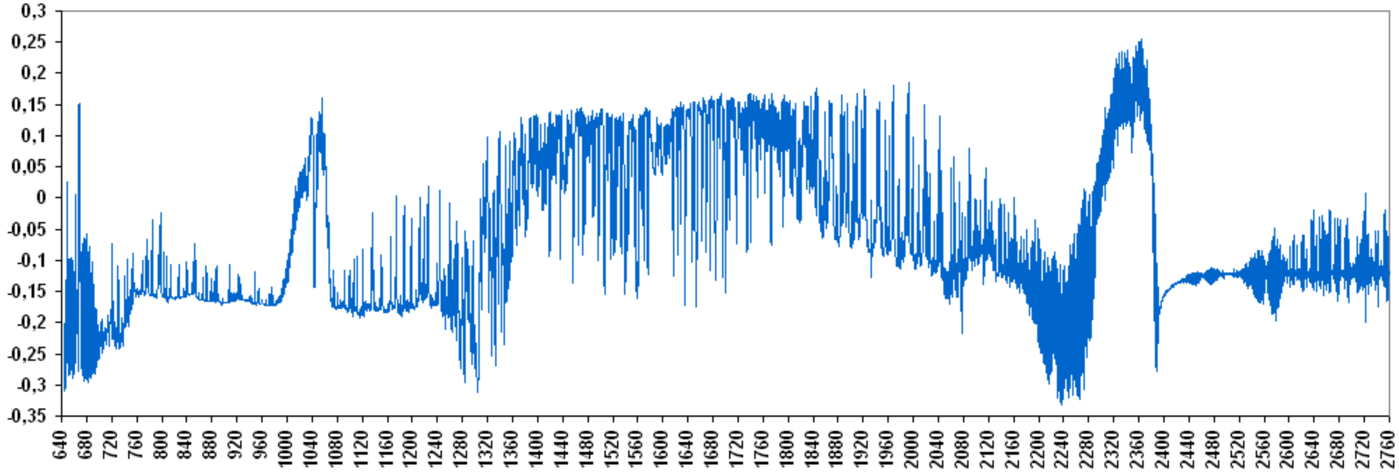




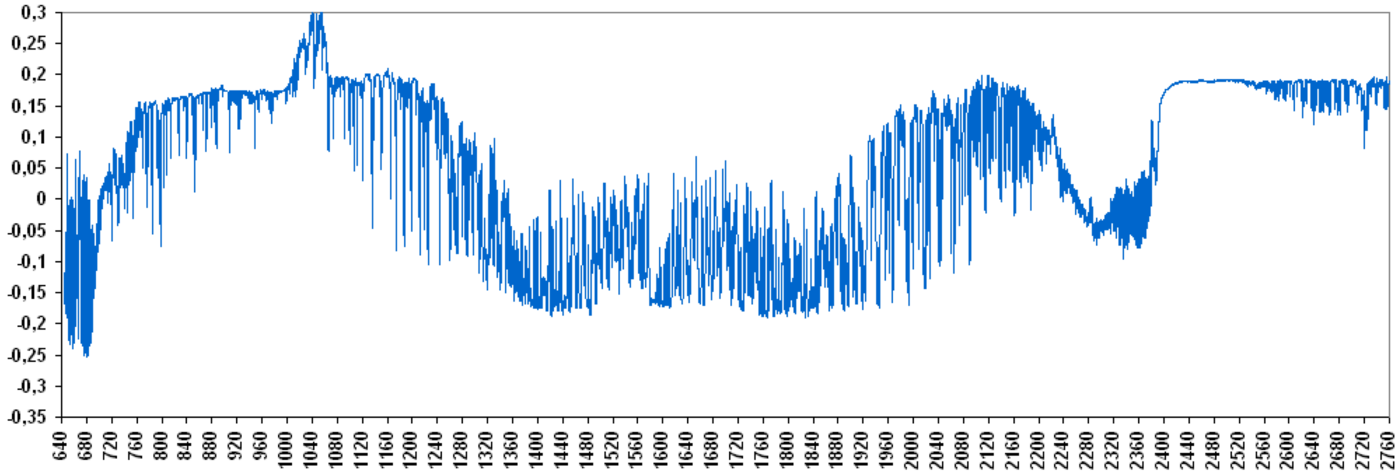
cnes

Year to year variations (2)

Clear Ocean June 11 to May 12 – June10 to May 11



Clear Ocean Jan 12 to Dec 12 – Jan 11 to Dec 11



Inverse ECVs Variations

$$\Delta T_B(T) = \sum_{nl=1}^{nl=3} \frac{\partial T_B}{\partial T}(nl) * \Delta T(nl) + \sum_{ngas=1}^{ngas=5} \frac{\partial T_B}{\partial q_{gas}} * \Delta q_{gas}(ngas)$$

Year	Ts	Ta				Humidity	CO_2	Ozone	N_2O	CO	CH_4
		LT	UT	LS	US/MS						
June 11 to May 12 - June 10 to May 11	-0.1 -0.1	-0.05 -0.05		-0.22 -0.13	1.6 1.0	-1.4% -2%	1.05% 0.96%	-2.3% -2.5%	4% 1.5%	0.4% 1.2%	1.3% 1%
Jan to Dec 2012-2011	0.05 0.03	0.06 0.18		0.10 0.08	-1.0 -1.0	2.4% 5.6%	1.05% 0.96%	-0.4% -0.2%	2% 0.6%	0.4% 0.4%	1.3% 1.3%

- Inversion performed based on presumed value of CO_2 mean variation
  - Simple assumptions
  - Inversion for regions where only one component is important
  - Iterative process until good fit
  - Values of Jacobians for mean atmosphere (here mean tropical, mean MLS, 1050 more suitable)
- Inversion matrix
- Include low troposphere

Annual Global Temperature Anomalies
1950 - 2012

Consistent with NCDC outputs

Lower Troposphere

Annual Lower Troposphere

January–December	Anomaly °C	Anomaly °F
UAH	+0.16	+0.29
RSS	+0.09	+0.16

Mid-troposphere

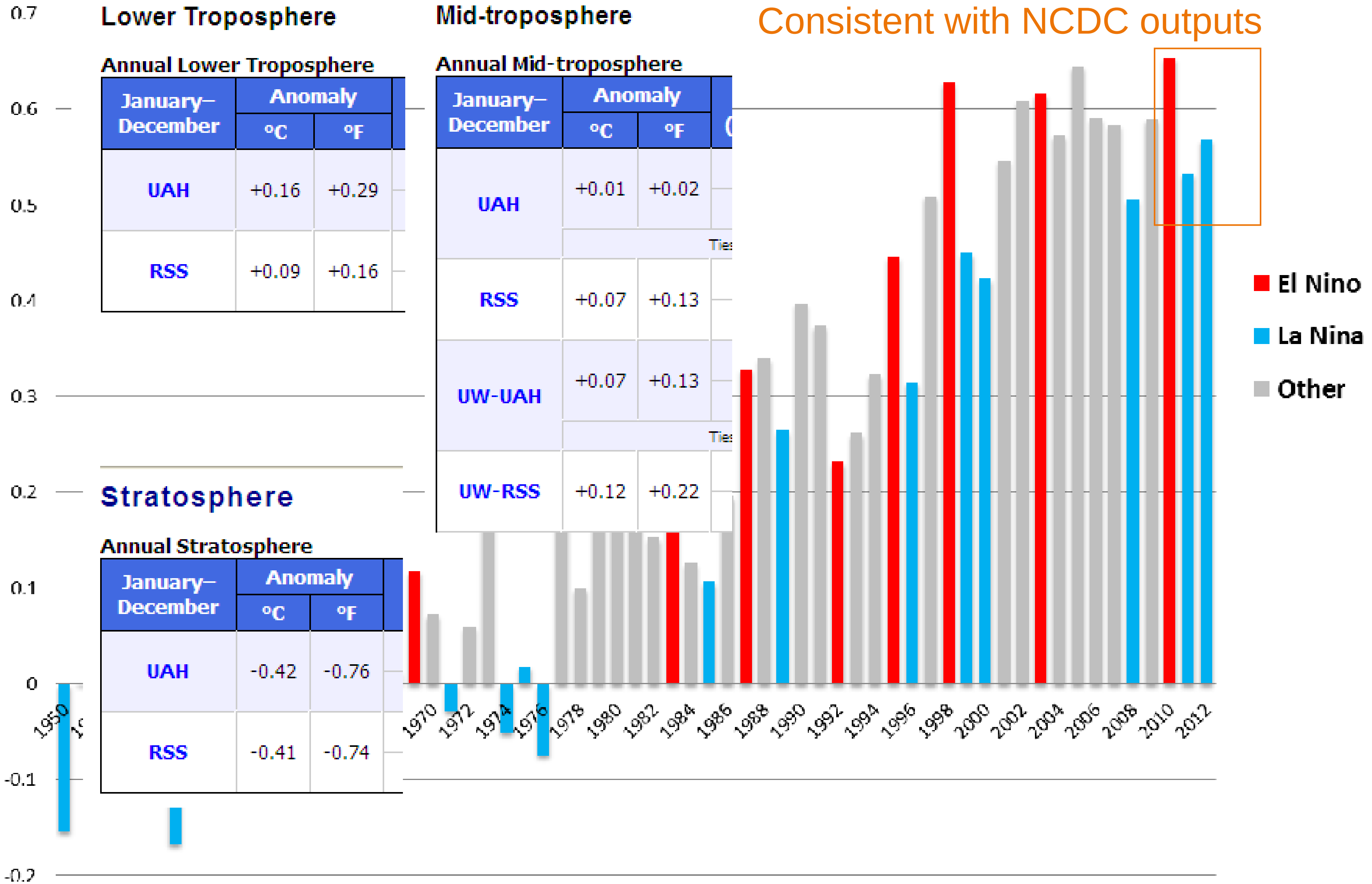
Annual Mid-troposphere

January–December	Anomaly °C	Anomaly °F
UAH	+0.01	+0.02
RSS	+0.07	+0.13
UW-UAH	+0.07	+0.13
UW-RSS	+0.12	+0.22

Stratosphere

Annual Stratosphere

January–December	Anomaly °C	Anomaly °F
UAH	-0.42	-0.76
RSS	-0.41	-0.74



Terminé

http://www.ncdc.noaa.gov/sotc/global/2012/13

cnes

Month by month analysis

Year 2010 warmer than 2012 and then 2011. How does it varies month by month ? Are there months of the year where deviations can be strong?

To analyze these points

- First Look at Year 2012 and gradients by month.

- Then analysis of monthly anomalies between the years 2010-2011- and 2012.

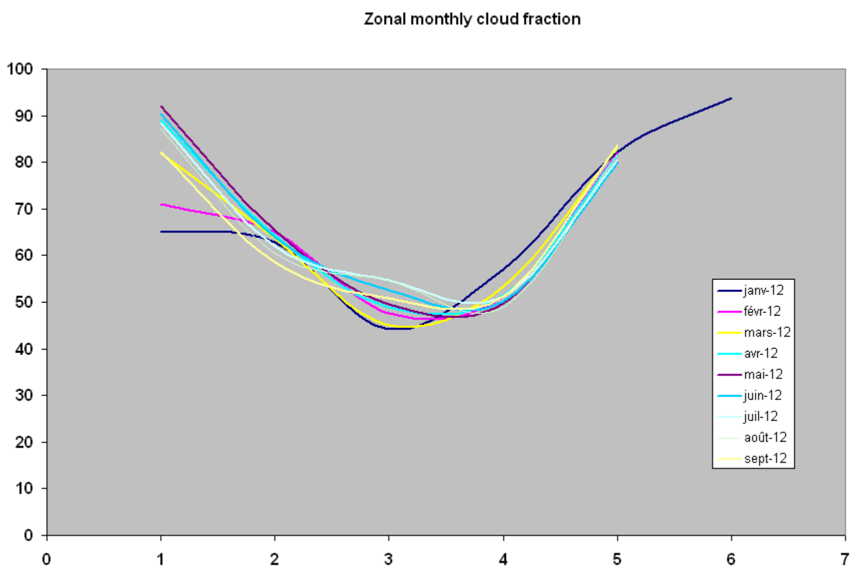
Summary on Climate analysis

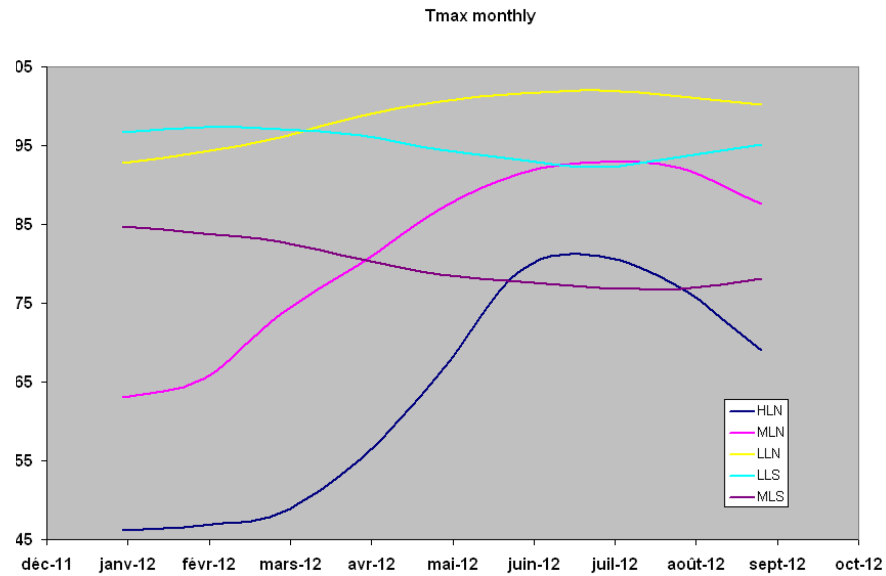
- IASI Level 1C spectra climatology brings a new tool for climate analysis
  - Allows with a same tool to get several variables all over the globe
    - Consistency between variables
    - Consistent observations in different regions to analyze potential teleconnections
- Comparison betwen 2 Niña (2010, 2011) with a (almost) regular year (2012) at global scale
  - No variation of cloud cover
  - Mean Surface Temperature warmer in 2012 than 2011 but 2010 the warmest
  - Cloud free OLR indicator slightly higher in 2012,
  - 2011 dryer than 2012 and and 2011 same as 2010.
- Month by month comparison
  - Monthly gradients more pronounced in 2012
  - Differences occur for surface and low atmosphere, in February (<0) and May (>0).

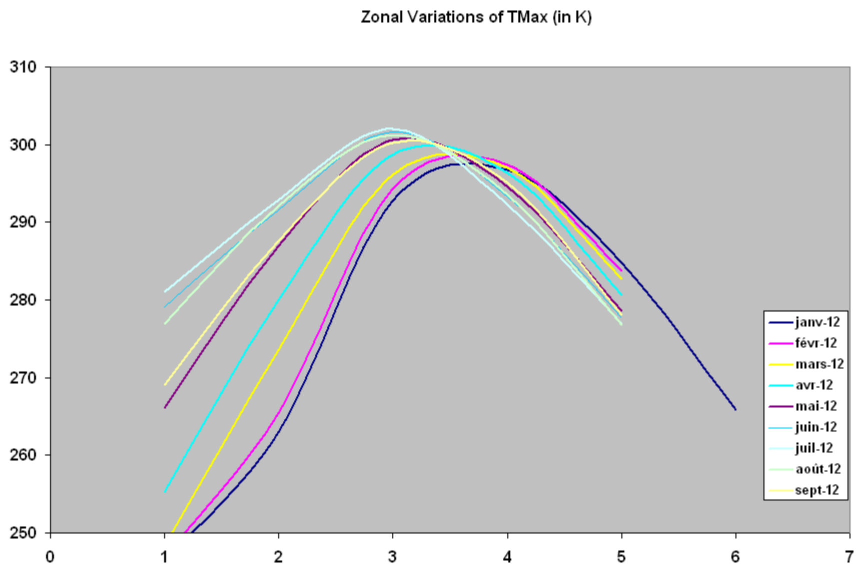
Climatology by bands of latitude

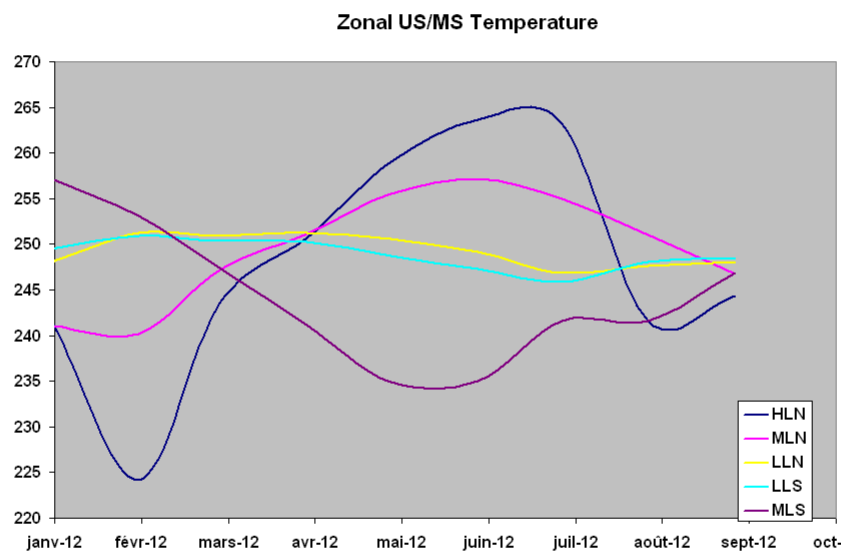
- Bands : HLN: [90,60°N], MLN : [60,30°N], LLN : [30,0°N],

  LLS : [0,30°S], MLS: [30, 60°S], HLS : [60, 90°S]

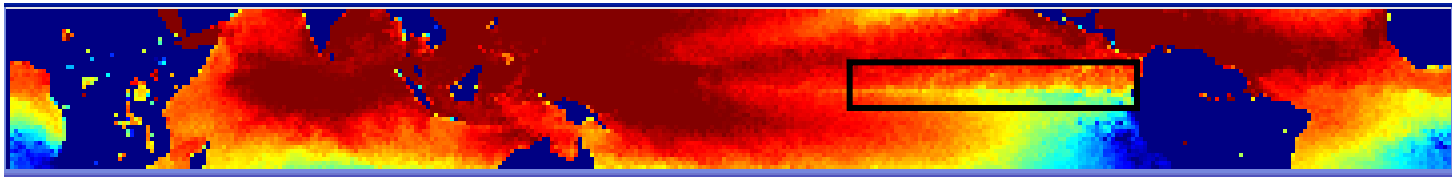


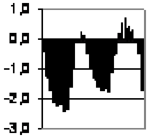


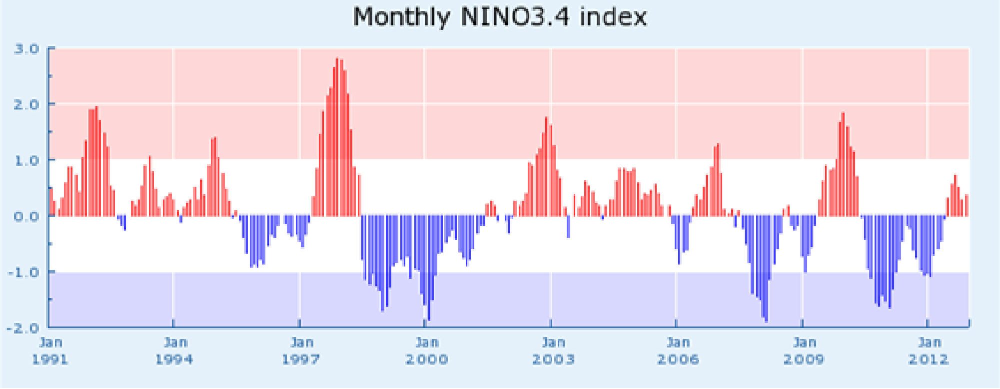




STUDY OF ENSO EVENTS







- Monitoring of ENSO 34 area.
- With monthly SST measured by IASI at night with channel 2616.75 cm^{-1} + mean aerosol correction and emissivity correction

Summary on the methodology

- IASI Level 1C spectra climatology such performed is very rich in information
- Very simple to implement
- Allows consistent access to various ECVs
  - And a qualitative evaluation
  - Very simple to inverse
- It also evidenced the very high quality of IASI data and processing and is a good tool to check any trend or artifact

Next steps

- Take into account feedback of the community
- Simulate mean IASI spectra month by month with ERA Interim reanalysis and confront.
- Continue with statistics for latitudinal zones.
- Define new regions
- Compare IASI-A with IASI-B
- Continue integration of new monthly products
- Make the data avaialble to the community

Reprocessed IASI L1C products for 2007 – mid 2010 URGENT !!!!

THANK YOU FOR ALL!