# Outline

- WRF model and regional climate modelling
  - Why clWRF?
- clWRF contents (present day)
  - GHG gases concentration
  - Surface extremes from internal time-steps
  - 'Heavy staff': gust winds
  - Additional values on time-series outputs
- clWRF what's next?
  - CCRC modifications: 5,10,20,30,1H wind and temp. extremes, GHG on rrtm
  - CORDEX variables?
  - New WRF output using ASCII variables external file
  - Other RCM needs?

# WRF and regional cliamte modelling

- Although WRF-ARW was conceived for (web page):
  - Idealized simulations (e.g. LES, convection, baroclinic waves)
  - Regional and global applications
  - Parameterization research
  - Data assimilation research
  - Forecast research
  - Real-time NWP
  - Hurricane research
  - Coupled-model applications
  - Teaching
- WRF lacked of some 'specific' regional climate modelling capabilities

# WRF and regional climate modelling

- Regional climate drawbacks of WRF (before clWRF...)
  - Green House Gases (GHG) concentrations 'fixed'
    - CAM radiation scheme has A2 CO2 evolutions prescribed in the code
    - No changes in other gases
    - No flexibility to use other scenario concentration evolution
  - Inconsistency between WRF output (instantaneous values) and surface minimum/maximum temperatures/winds/... (given from minute measurements)
  - CORDEX require new variables that they can not be computed using standard WRF output, such as: sunshine length, wind-gusts, surface downward East/Northward wind stress,...
- It was necessary to tackle these issues... even if did mean that WRF code should be modified... :)

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# clWRF. Improving WRF utility for RCM

- In the frame of the Spanish ESCENA project, *Universidad de Cantabria* was pioneering the use of WRF model for Regional Climate Modelling in Spain
- Most of the WRF climate-drawbacks had to be fixed → clWRF (Fita et al., 2010, 11th WRF workshop)
- Modifications have to be easily introduced and easy to activate/deactivate
- http://www.meteo.unican.es/wiki/cordexwr f/SoftwareTools/ClWrf

# clWRF. 'Light' modifications

- Measured accumulations of precipitation differ in each country... 8 to 8, 7 to 7, ...
  - Include precipitation in auxiliar output #4 to define new daily accumualtions
- Compilation activation:
  - In order to know which version of WRF is running, a message has been added in
    `WRFV3/main/module_wrf_top.F`
- All clWRF modifications in the code have #CLWRF comments in `[file].F` source code files

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# clWRF. GHG concentrations

- CAM lw/sw radiative scheme had included (v3.1) the evolution of $CO_2$ concentrations
  - Fixed in the code as a Fortran data statement (only A2)
- Design/purpose:
  - Introduce flexibility on the GHG temporal evolution, more scenarios, sensitivity studies...
  - Use an external ASCII file as the input of the GHG concentrations

# clWRF. GHG concentrations

- Activation during the compilation when
  - `-DCLWRFGHG` is used
- Two modules have been modified:
  - `WRFV3/phys/module_ra_cam_support.F`
    - Necessary modifications to avoid the use of the prescribed A2 values
  - `WRFV3/phys/module_ra_cam.F`
    - Reading of the values from external ASCII file (Fortran fixed format)
    - Linear interpolation using the Julian day of the year

# clWRF. GHG concentrations

- An external ASCII file is read with the evolutions of the concentrations of the GHG
  - CAMtr_volume_mixing_ratio: External ASCII file
  - $CO_2$, $CH_4$, $N_2O$, CFC-11, CFC-12. A missing value can also be used
  - Flexibility on temporal frequency
  - Any scenario
  - Any sensitivity test
- Two new files for RCP 4.5 and 8.5 have been already prepared to be used… soon in the web page!
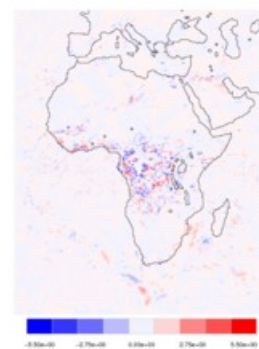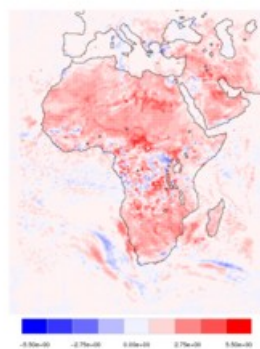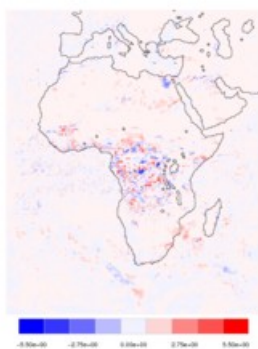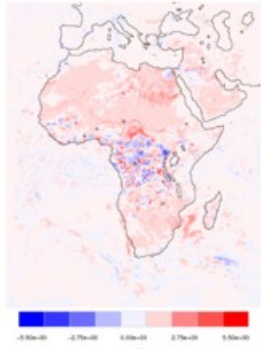
# clWRF. GHG concentrations

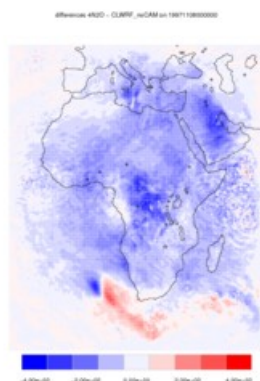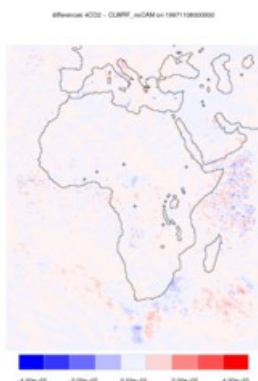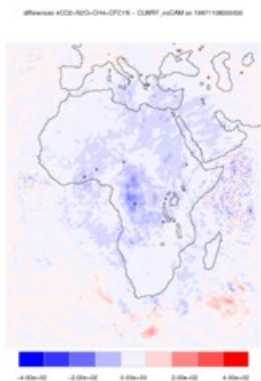| 4CO2+4N2O+4CH4+4CFC1N | 4CO2 | 4N2O | 4CH4 | 4CFC1N |
|---|---|---|---|---|

**temp**

**precip**

**psfc**

# clWRF. Extreme values

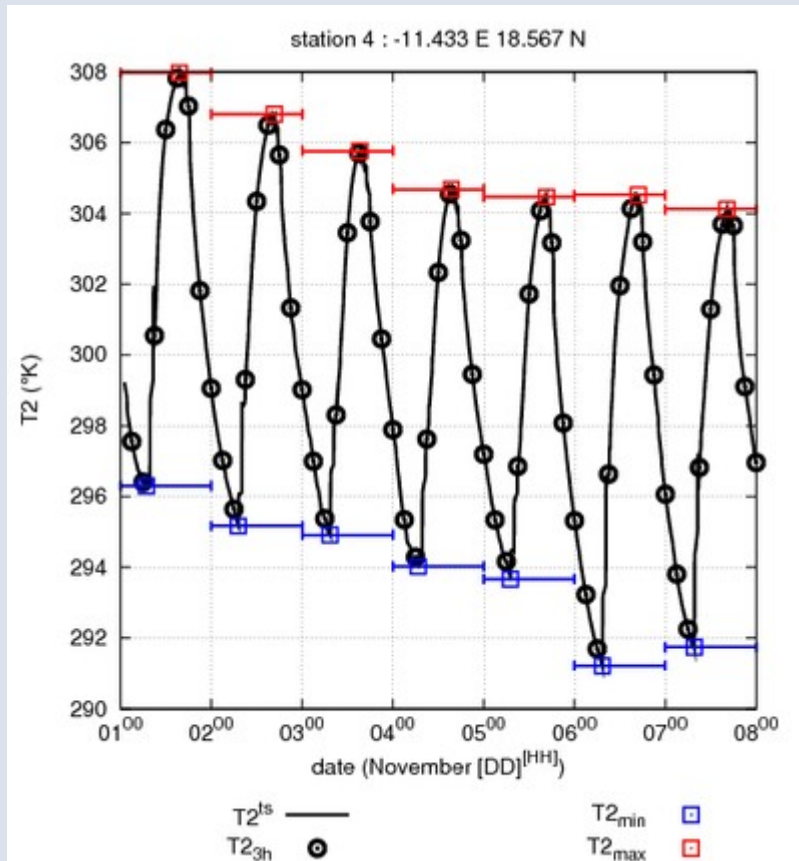- Extreme values have to be computed using internal time-steps (temporal frequency at which equations are solved)
- Much more closer to reality/measurements
- New set of diagnostic/modules have to be introduced
- Significant modifications on WRF code
- Introduction of new variables in WRF output... modify `Registry.EM` file...

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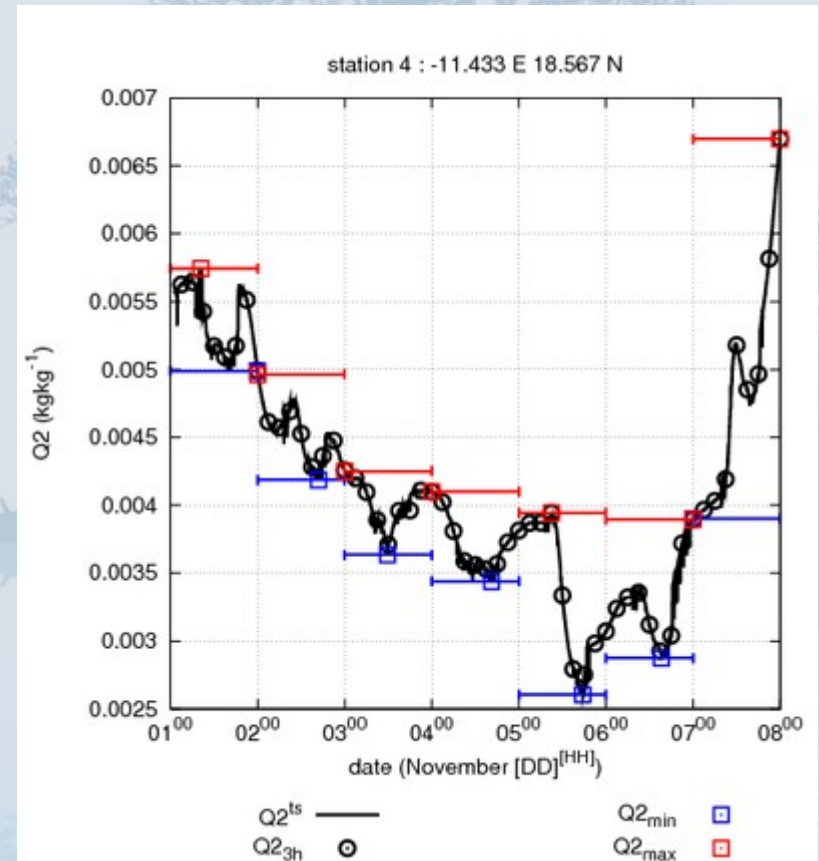SYDNEY • AUSTRALIA

# clWRF. Extreme values

- **Activation in compilation with** `-DCLWRFXTR`
- **Activation in namelist with** `output_diagnostics`
- **Modification of:**
  - `WRFV3/dyn/solve_em.F`
    - **Call to a new module (subroutine) with the computation of the extremes**
  - `WRFV3/phys/module_diagnostics.F`
    - **New subroutine** `clwrf_output_calc`
  - `Registry/Registry.EM`
    - **Definition of new statistical variables**
    - **Extreme values to be written in auxiliar output #3**

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# clWRF. Extreme values

**2m Temperature**

**2m Mixing ratio**

# clWRF. CORDEX variables

- Activiation during the compilation using `-DCLWRFHVY`
- Two additional variables have been included: sunshine length and gust wind with additional ones related to moving/fixed temporal accumulations
  - Sunshine length: accumulated period of short-wave radiation above 120 Wm2 (WMO)
  - Wind-gust: following Brasseur, 2001
- Modification of:

  - `dyn_em/solve_em.F`
    - **Call to new specific subroutine**
  - `phys/module_diagnostics.F`
    - **New subroutine** `diagnostic_clwrf_clim` **for: sunshine, wind-gust, precipitation accumulations**
  - `share/output_WRF.F`
    - **Inclusion of some definitions for restart purposes**

# clWRF. CORDEX variables

- Some variables are computationally expensive
- Activation with independent `namelist.input` variables
  - `clwrf_sunshine`: sunshine
  - `clwrf_gust_wind`: gust wind
  - `clwrf_accum_precip`: accumulated precipitations (moving/fixed)
    - `timesteps1_movaccum`: number of time-steps
    - `Fixtimeaccum`: fixed accumulation (total seconds)
- Output written in auxiliary output #5

# clWRF. Extra variables

- Accumulated maximum moving precipitations
- modification of:

  - `WRF/phys/module_diagnostics.F`:
    - Computing new accumulated values. A vector of accumulated precipitations is used (`t - timesteps1_movaccum - 1, …, t-dt, t`)
    - accum(t) = $\Sigma$ raintot (t-timesteps1_movaccum: t)
  - `Registry/Registry.EM`:
    - Addition of new variables. Definition of new dimension for the vector with the period of accumulation
  - `WRFV3/Registry/registry.dimspec_CLWRF`:
    - Addition of the new dimension 'mov' of size `timsteps1_movaccum`

- **NOTE:** It is not working with restart files
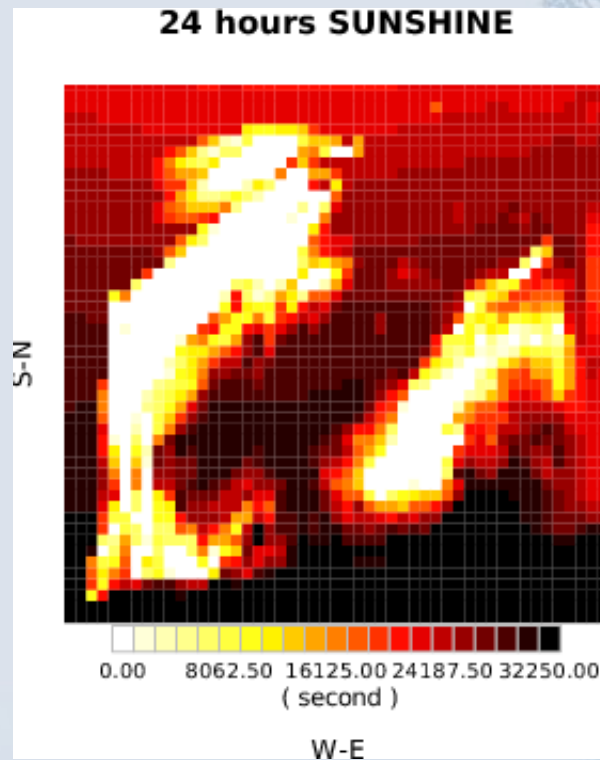
# clWRF. CORDEX variables

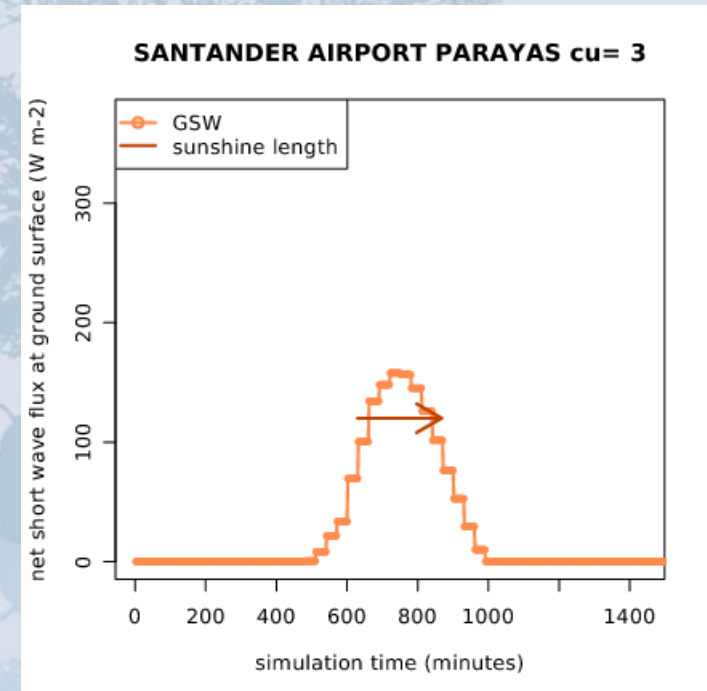## Sunshine
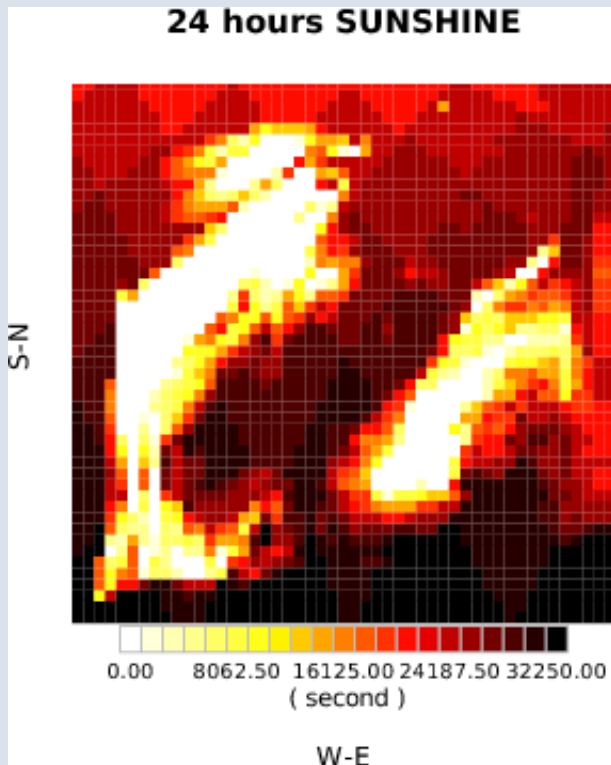


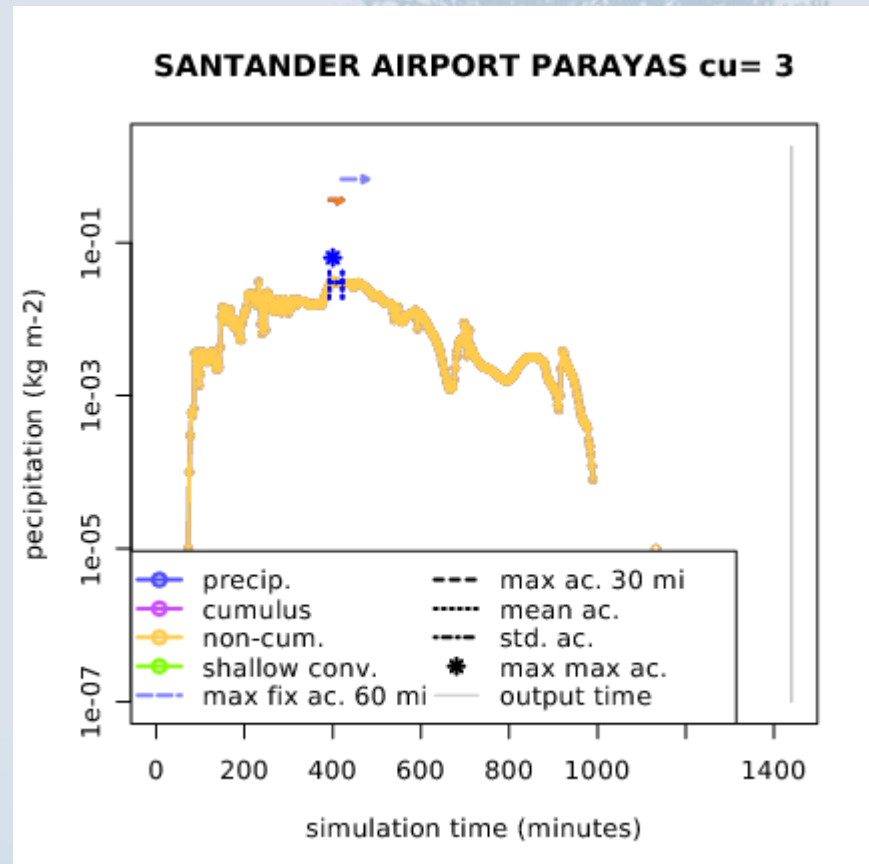radt = 30            radt = 0

# clWRF. CORDEX variables

Moving accumulated precipitation
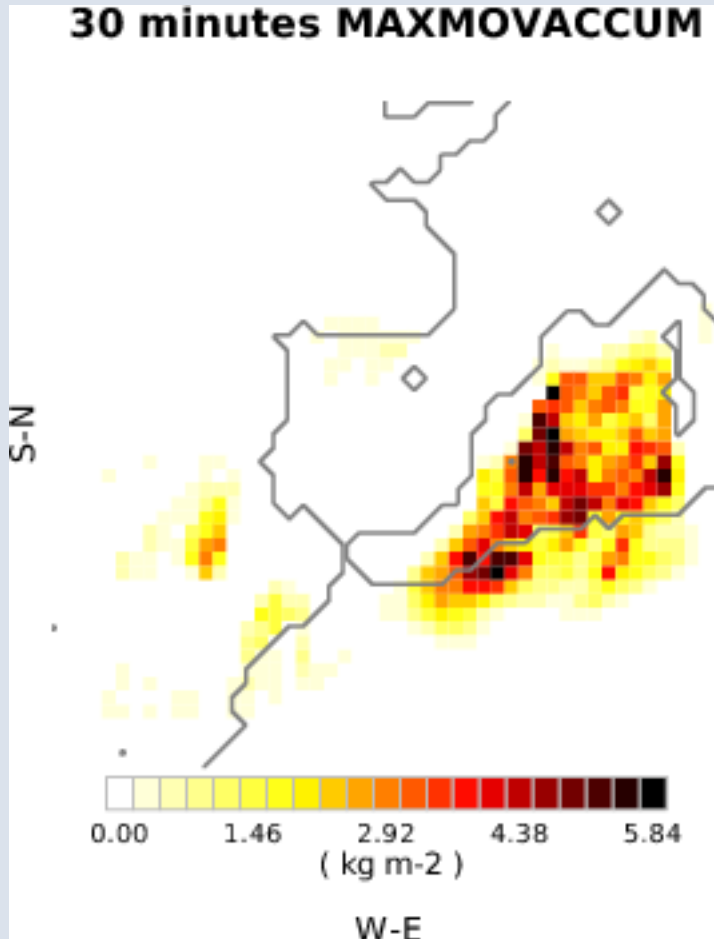
# clWRF. Extra variables

- New variables can be outputted in the *time-series* ASCII files (`tslist`)
- Variables related to planetary boundary layer studies which are usually measured a very high temporal resolution on a unique place
- modification of:

  - `WRF/share/mediation_integrate.F`: **Call to new I/O time-series subroutine**

  - `WRF/share/time_series.F`: **output of new variables: pblh, tkesfcf, ust, rmol, mol, regime, ck, cd, capg, thc**

- **Activation in** `namelist.input` **using variable:** `clwrf_ts_pbl`

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# clWRF. Extra variables



SANTANDER AIRPORT PARAYAS cu= 3
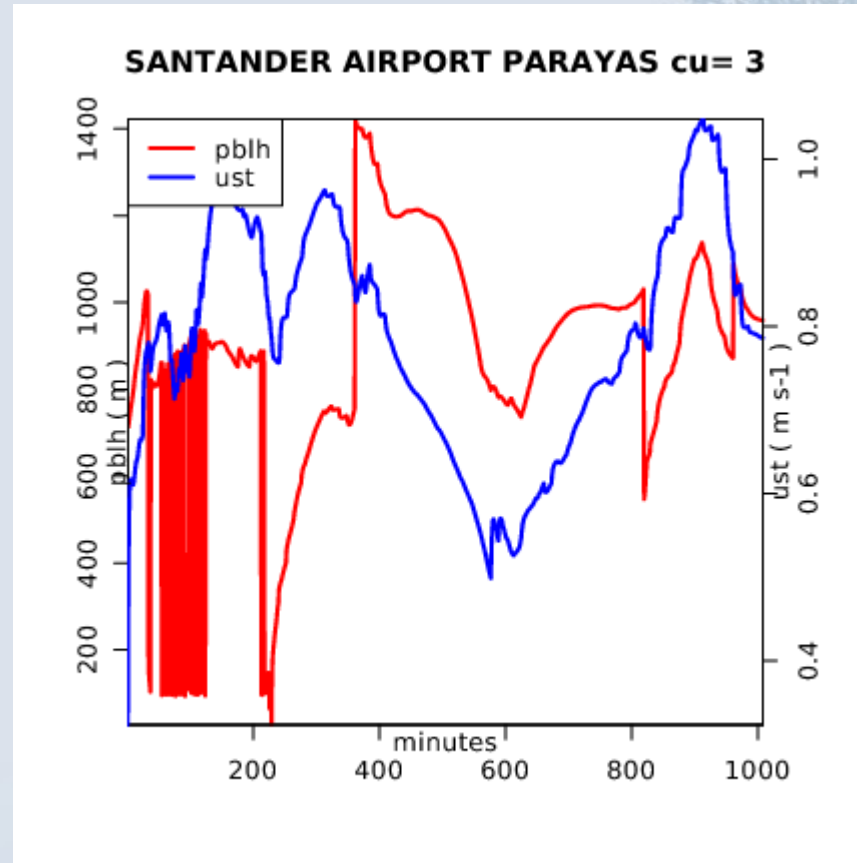
# clWRF. Summary

| clWRF | Compilation flag | namelist option | # Aux output |
|---|---|---|---|
| extremes | **Already in WRF** | `output_diagnostics` | 3 |
| GHG assimilation | `-DCLWRFGHG` | | |
| sunshine | `-DCLWRFHVY` | `clwrf_sunshine` | 5 |
| gust wind | `-DCLWRFHVY` | `clwrf_gust_wind` | 5 |
| time moving acc. | `-DCLWRFHVY` | `clwrf_accum_precip`<br>`timesteps1_movaccum`<br>`fixtimeaccum` | 5 |
| Add. time-series | `-DCLWRFHVY` | `clwrf_ts_pbl`<br>`max_ts_locs (&domains)` | |

- All namelist options in `&time_control` section
- Compilation options are declared in `configure.wrf` file (example, following line after `-DNETCDF`), and related to the pre-processor following -D[flag]

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# clWRF. What's next?

- Climate Change Research Center (C. Carouge) improved/enhanced clWRF modifications
  - External GHG ASCII file input in rrtm radiative scheme
  - New accumulated precipitation and wind maximum values for 5,10,20,30 minutes and 1H
  - Internal re-code of certain parts of the clWRF. New module
  - **NOTE:** This modifications are **NOT** in clWRF modifications from *Universidad de Cantabria*.

# clWRF. What's next?

- clWRF specific:
    - Coordinated effort. We are waiting your contributions/ideas !
        - 92 users (Sep. 21st 2012)
    - clWRF generalization GHG gases and extreme variables
    - GHG ASCII file reads need to be moved to `module_ra_cam_support.F` instead of `module_ra_cam.F`
    - New CORDEX variables to be included? Surface downward East/Northward Wind Stress
    - Need to converge clWRF and CCRC modifications in WRF 3.4 and beyond. **CORWES task?**
    - clWRF (only extreme values) in WRF code since v3.3.1
    - Explore utility of external ASCII files for the output variables as a way to compute new extreme/statistics values (WRF developers? J. Dudhia) e.g.:
        - `+:h:0:[stat]:RAINC,RAINNC      [stat]=n,x,m,s`
    - **Main goal:** Include all clWRF in standard WRF code

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# clWRF. What's next?

- Does the Regional climate modelling community need more new capabilities from WRF?
- Time to talk and plan !

- Possible schedule:

    i. Open a clWRF track/repository/forum system
    ii. Converge clWRF with CCRC in 3.4
    iii. Push clWRF to standard WRF code (R. Leung + J. Dudhia)
    iv. Introduce new features (following a standard methodology, specific compilation flag and namelist option). Users have to be able to run WRF wihout any modification

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