Optical Turbulence Forecast applied to ground-based astronomy

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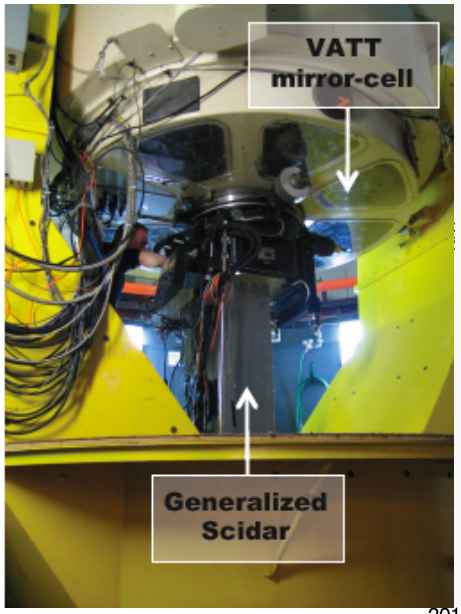
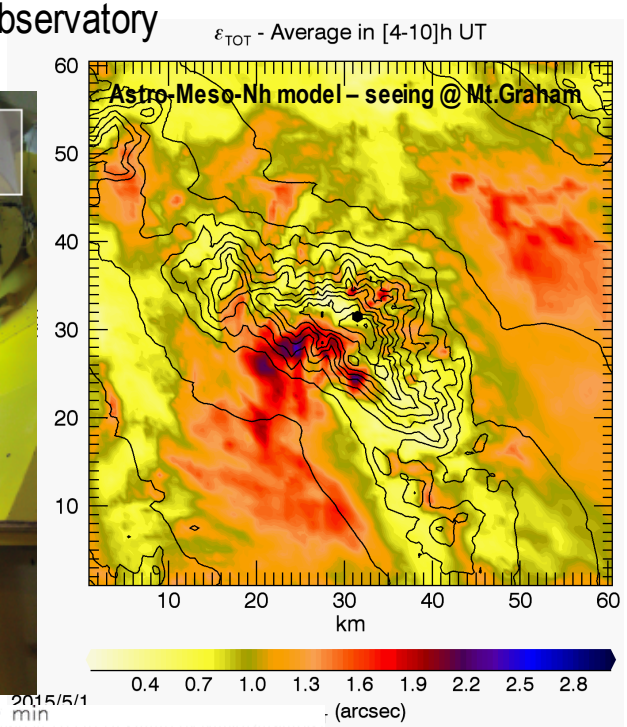
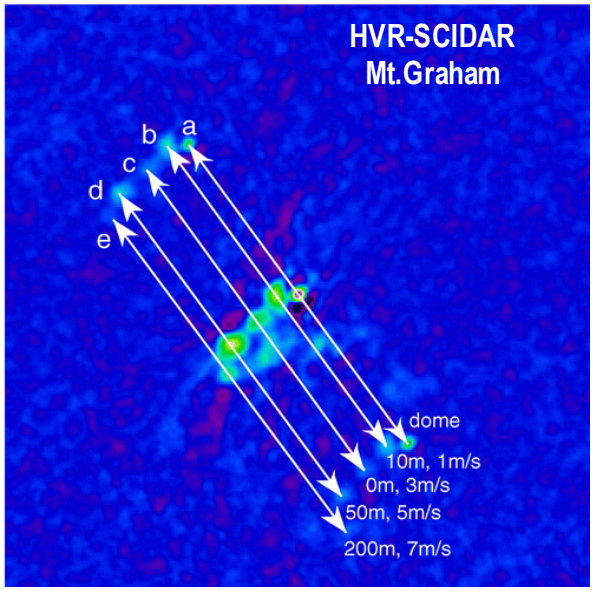
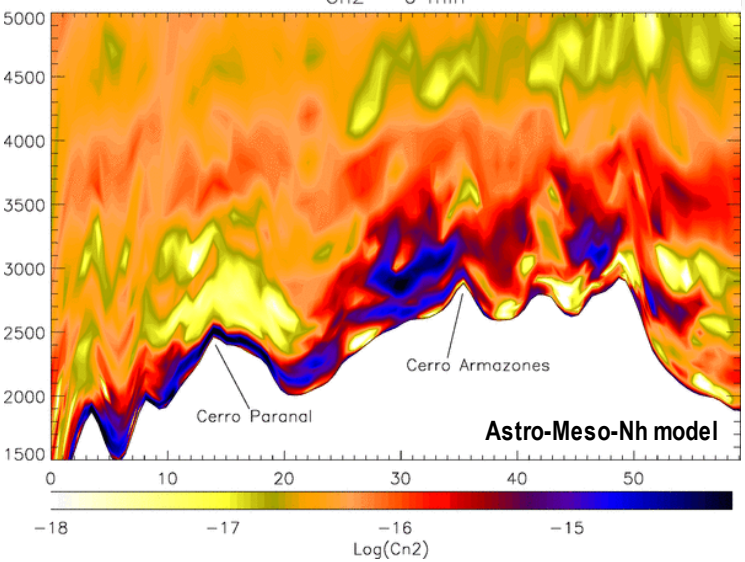
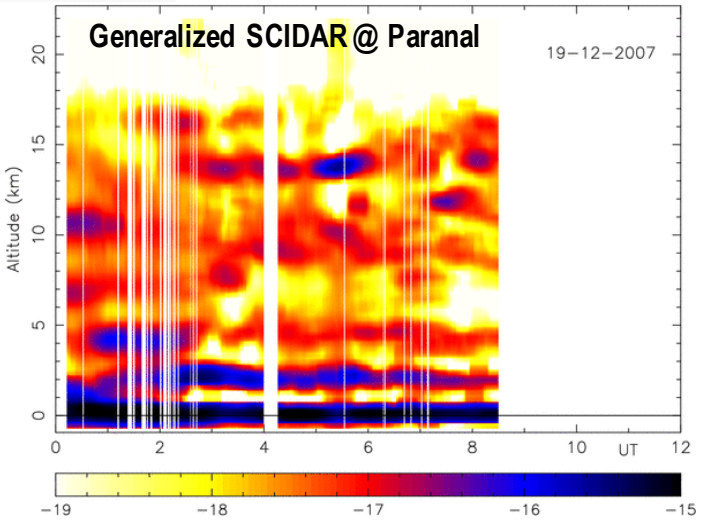






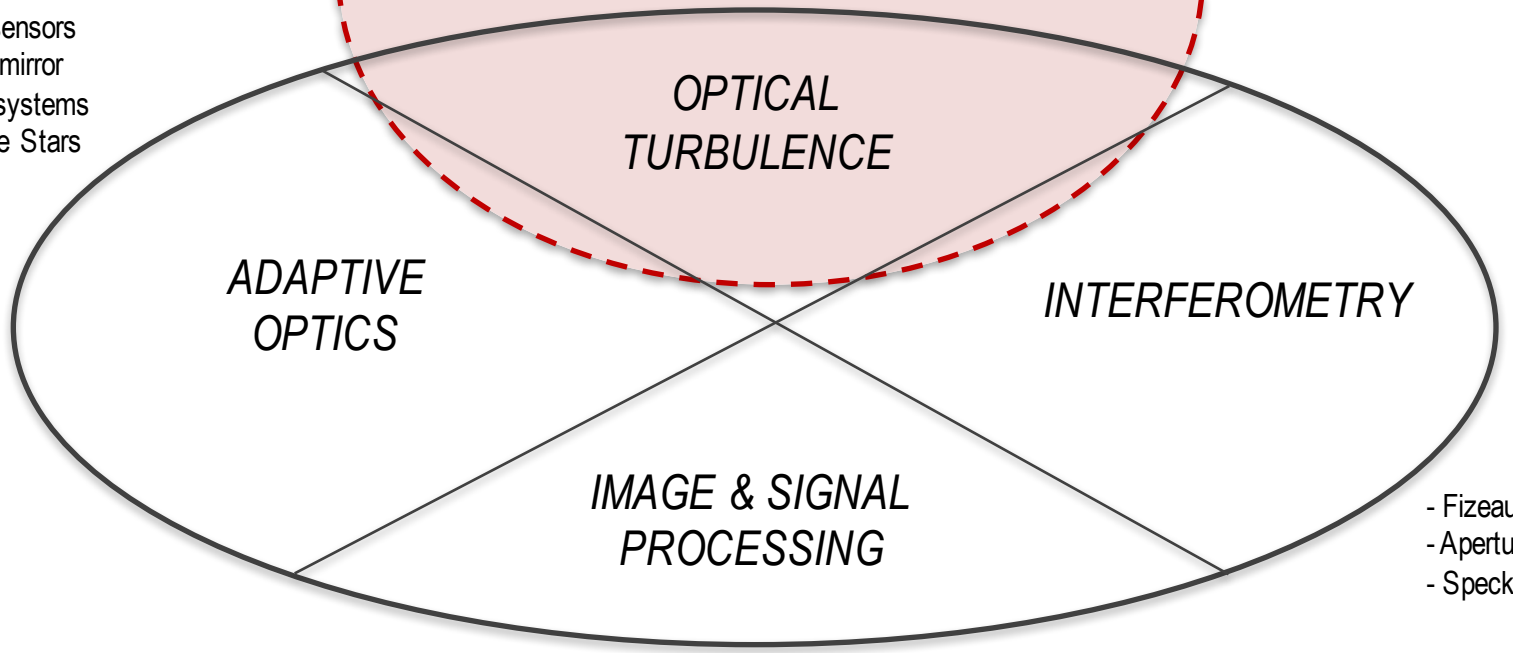




High Angular Resolution Techniques

OPTICAL TURBULENCE FORECAST

- ***Modelling – mesoscale models***
- ***Optical turbulence parameterization (numerical algorithms)***
- *Instrumentation to measure OT*
- *Site testing*
- *Applications to AO instruments*
- *Turbulence: 'basic research'*



-Wave front sensors
-Deformable mirror
-AO Control systems
-Lasers Guide Stars
-Extreme AO
-WFAO

- Fizeau-Interferometry
- Aperture synthesis
- Speckle interferometry

- High contrast imaging processing (SDI, ADI…)
- Coronography
- Scintillaton effects on direct imaging
- PSF reconstruction

OPTICAL TURBULENCE FORECAST: SCIENTIFIC DRIVERS

1) Traditional queue system : *High scientific challenge of the program* **PARADOX** *Low probability that the program is executed*

2) Service Mode is a must to optimize the exploitation of an ELT

3) Adaptive Optics techniques are strongly dependent from the OT conditions

4) Cost of a night of observation at a top-class telescope is of the order of 100 K$!!!

5) The advantages of the Service Mode can be fully achieved **ONLY** if most of the available observing time is scheduled in this mode

The Service Mode has been established to be the baseline observing mode at the E-ELT (E-ESO-SPE-066-0283)

Permanent instruments at different focal stations. Typical time required to move the beam from an instrument to another one: ΔT_{min} **~ 10-20 min**. (E-ESO-SPE-066-0283)

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2) S

3) A

4) C

5) T

the E-ELT" (E-ESO-SPE-066-0283)

★ The *optical turbulence forecast* is fundamental for the ***success*** of the ELTs

★ *Measurements* ***can not*** provide this information

★ *Non-hydrostatical mesoscale models* are ***the unique tool*** that can attain such a scientific goal

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ALTA Center: Advanced LBT Turbulence and Atmosphere Center

Operational system for the forecast of OT and atmospherical parameters relevant for ground-based astronomy @ Mt.Graham (LBT) ***funded by LBT Consortium***

Important: project on long time scale (continuum evolution)

Milestones:
- **December 2015**: automation completed
- **June 2016**: atmospherical parameters (online) - *commissioning*
- **December 2016**: astroclimatic parameters (online) - *commissioning*

Feasibility study ***funded by ESO***
Phase A: *[4/2011 – 4/2013] – two years*
Phase B: *[6/2014 – 6/2015] – one year*

On 17 March 2016 we concluded negotiation with ESO for a '***DEMONSTRATOR***':
- Starting date: December 2016
- Budget defined
- Duration: 2 years

Goal: *managing OT forecasts above different astronomical sites*

A few facilities with D ≥ 6.5 m around the world

pictures with red frames: facilities with our operational system
pictures with green frames: we performed just studies not yet operational system
pictures with yellow frames: preliminary contacts

PERSPECTIVES

TOPIC
OPTICAL TURBULENCE FORECAST in ASTRONOMY

CHALLENGES SCIENTIFICI

- **L'affidabilita' dei sistemi di AO e' certamente uno dei temi portanti della prossima decade**
  ➔ previsione della OT e' fondamentale
- Abbiamo solida 'expertise' riconosciuta internazionalmente (ben piazzati per imporci nel campo)
- Turbolenza in regime stabile e' tra i 'problemi aperti' piu' critici della fisica classica

INAF – Arcetri
Italy

(France)

Centre National des Recherches Meteorologiques

(Italy)

(Germany)

(UK)

European Centre for Medium Range Weather Forecasts

RISORSE DI CALCOLO

competitive call
SAC: Scientific Allocation Time Committee
TAC: Technical Allocation Committee

RICERCA: APPLICAZIONE OPERAZIONALE

LOCAL SERVERS
~ 10 Keuro
(importanti per poter gestire/testare condizioni operazionali)

SuperMicro (Opteron)
64 proc.
128 GB RAM

Importante la rapidita' di calcolo per applicazione operazionale

RICERCA

HPCF esterne
Super cluster ECMWF (UK)
"Special Projects"
Abbiamo ottenuto risorse di calcolo per due progetti:
2011-2013: ~ 2 Milioni di SBU ogni anno
2014-2016: ~ 2 Milioni di SBU ogni anno

SBU=System Bill Unit
dipende da CPU e RAM
82 Milioni SBUs available per tutta Europa ogni anno per Special Projects

LIMITE HPCF ECMWF:
Considerata l'alta richiesta

NO a progetti a lungo termine

RISORSE INAF (HPCF style) utili perche':
Ci permette di avere piu' facilmente tempo di calcolo per la parte di ricerca (la piu' difficile da stimare con precisione su scale temporali lunghe)

IBM Power 7
Batch scheduler: LoadLever
Operating System: AIX

Cray XC30 ➔ XC40
Batch scheduler: PBSpro
Operating System: Linux

QUESTIONARIO

Man Power: Masciadri (staff), Turchi (assegno), Fini (staff-system manager)
Tendency: prevista crescita man power (+)

Programs: Meso-Nh (modello atmosferico non-idrostatico a mesoscala) e Astro-Meso-Nh Parallelizzato - MPI

Linguaggio di programmazione: f90 (codici atmosferici idrodinamici non idrostatici)

Compilatori: gfortran / ifortran

Numero di cores:
@ server locali: 64 proc.
@ HPCF at the European Center for Medium Range Weather Forecasts (ECMWF)
(80 proc. max limite imposto dal modello)

RAM: max 128 Gb (quantita' dipende da hardware in a HPC)

Sistema Operativo: Linux

RISORSE UTILIZZATE

Risorse utilizzate:
- Servers locali
- HPCF cluster (IBM Power 7 or Cray – ECMWF)

Struttura
- Fondi personali
- Altri Enti [HPCF cluster (IBM/Cray – ECMWF)]

Uso del sistema
- Server locali: giornaliero
- HPCF: periodi concentrati nell'arco di un anno

Tempo di calcolo medio
Molto variabile in quanto dipende dall'hardware e dal job:
Tipica simulazione 'costosa': 16h-48h (media: 22h) su HPC

Storage usato in totale: on 7/6/2016: ~ 47 Tb
Fattore importante !!

Indipendentemente dall'hardware per il calcolo
siamo molto interessanti a sistemi di stoccaggio
centrali che possano servire in aggiunta alle disponibilita' locali

RISORSE PER IL PROSSIMO TRIENNIO

Immaginando di avere un HPCF simile a quelle usate fino ad oggi…...

Ore di calcolo: 10-15x10^3 ore di calcolo → 48h x100 sim in 1 anno x 3 anni

Storage: 8Tb

THE END
Thanks for the attention