

Benchmark study of simulation tools to model the solar irradiation on building facades



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Framework

The project was initiated in the G2solar project (INTERREG) : Validation of the solar cadastre of Geneva



Govehovitch et al. Appl. Sc. 2021

And then pursued within the IEA Task 63



- **Subtask A:** Solar planning strategies and concepts
- **Subtask B:** Economic strategies and stakeholder engagement
- **Subtask C:** Solar planning tools
- **Subtask D:** Case studies

Contributions

- IEA Tâche 63
- 7 Universités
- 1 Centre de recherche
- 3 Industriels



Urban solar resource is poorly exploited

- **Massive deployment** of urban solar energy system is expected
- Need for high temporal and spatial resolution of urban solar resource
- More and more tools, some of them relatively easy to use.
 - Are they reliable for high resolution?
 - What is the physic behind?

- Geometry: 2 districts (homogeneous and heterogeneous)
- Focus on the central building
- Location: Geneva
- Weather: 2 representative days (august and february)

DNI (Direct Normal), DHI (Diffu. horizontal) GHI (Global horizontal)

- Reflectivity coeff. 0.3

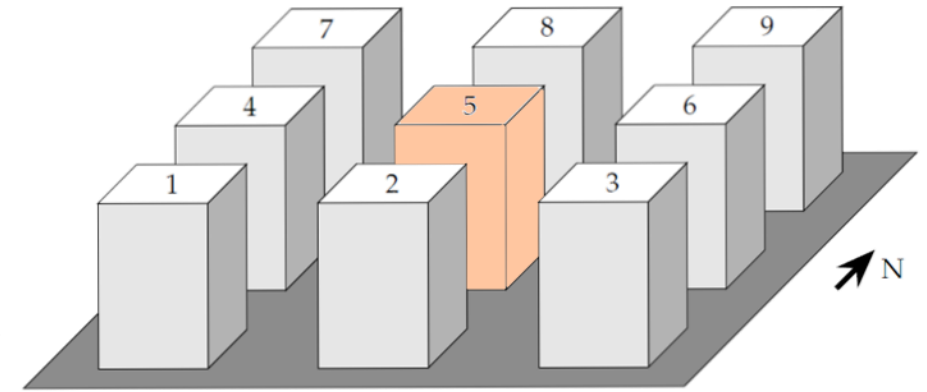


Figure 1. Sketch of the Homogeneous Neighborhood

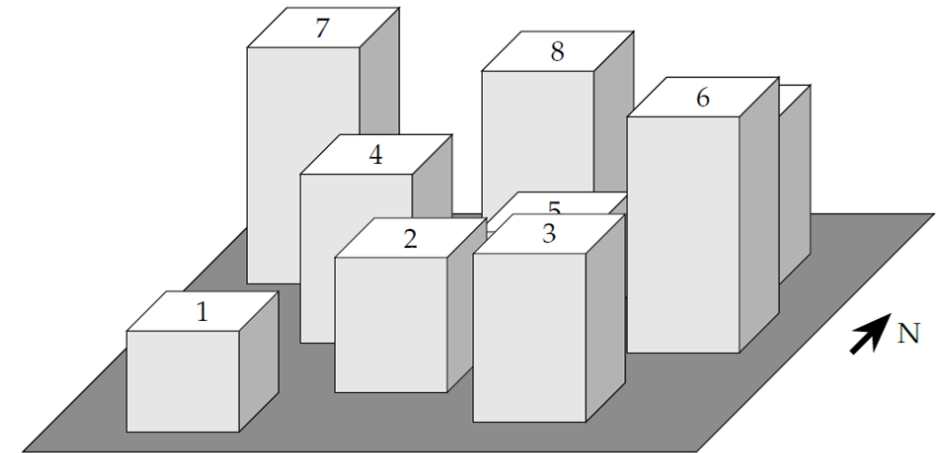


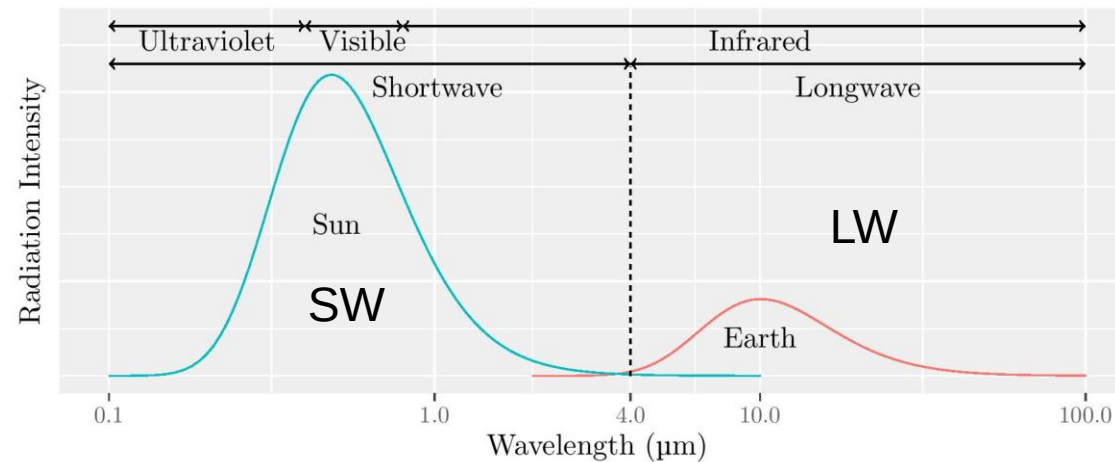
Figure 2. Sketch of the Heterogeneous Neighborhood

- Tools :
 - CitySim (Energétique de la ville)
 - Diva (Eclairage intérieur/extérieur)
 - EnergyPlus (Energétique du bâtiment)
 - EnviMet (Climat urbain)
 - Indalux (Eclairage intérieur/extérieur)
 - LadyBug-LB (Eclairage intérieur/extérieur)
 - Honeybee-HB (Eclairage intérieur/extérieur)
 - Solar Cadastre of Geneva (CadSol) (Cadastre Solaire)
- Expected contributions :
 - IDAice (Eclairage intérieur/extérieur)
 - SpaceMaker (BIM)
 - REVIT (BIM)
 - htrdr (MESO-star) (Rayonnement)
 - Archelios (Cadastre Solaire)



Tools specificities

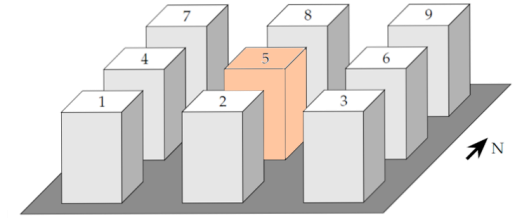
	SW	LW	Microclimate	Method	Simulation engine
CitySIM	Y	Y	N	Radiosity	Own engine
Diva	Y	N	N	Ray-tracing	Radiance
EnergyPlus	Y	Y	N	Ray-tracing	Own engine
Envimet	Y	Y	Y	Radiosity	Own engine
Indalux	Y	N	N	Ray-tracing	Radiance
HoneyBee	Y	N	N	Ray-Tracing	Radiance
LadyBug	Y	N	N	Ray-tracing*	Radiance
CadSol	Y	N	N	Radiosity	Own engine



* Without reflections

Cumulative energy

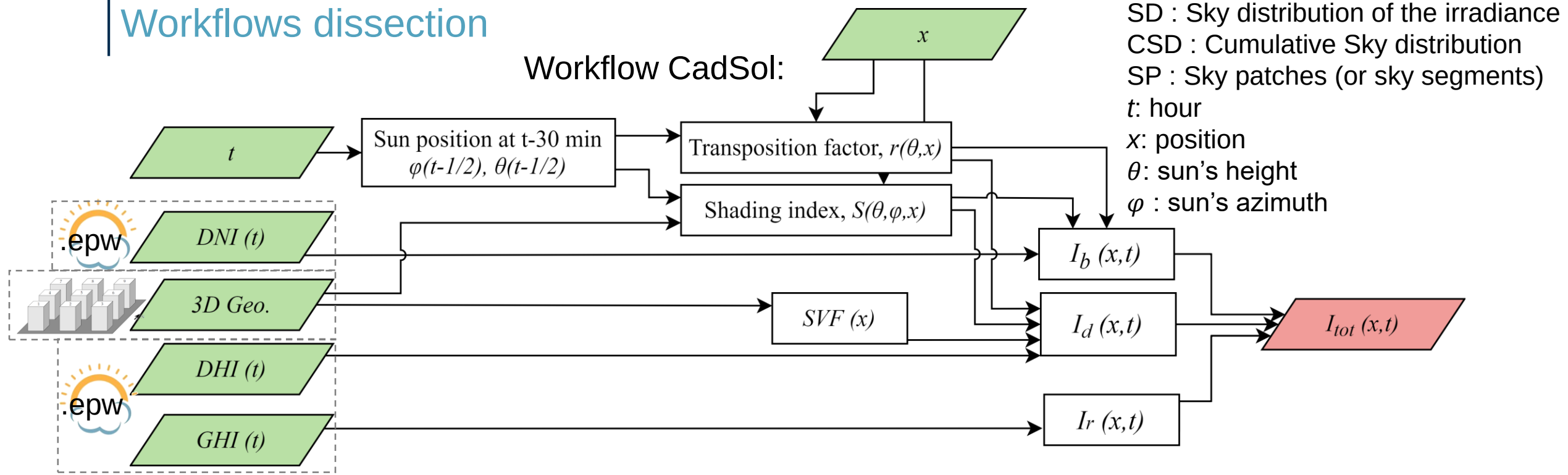
Daily cumulative radiation (in Wh/m²) received on each facade for the considered tools. Case of a homogeneous district in February. **The blue and red colors respectively indicate the minimum and maximum values**



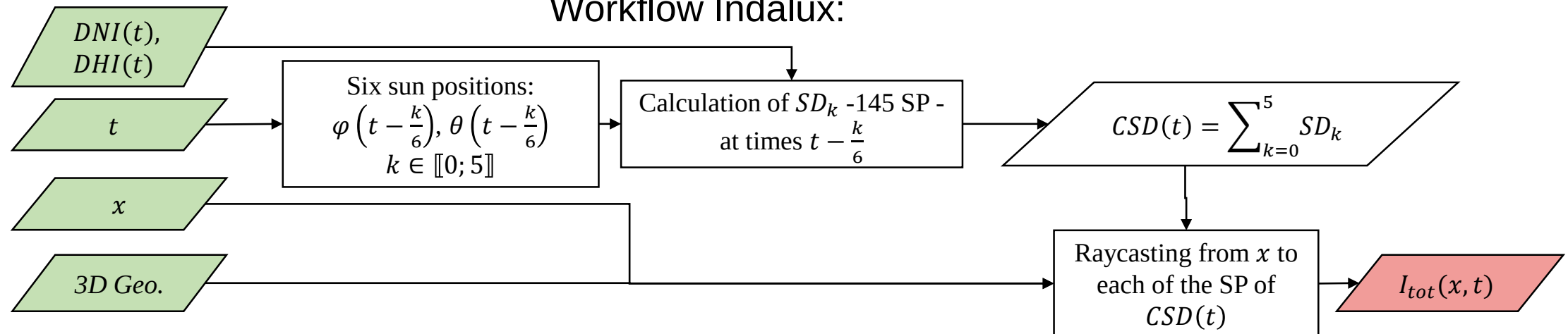
	Roof	East	West	South	North
CadSol	1986	950	742	1554	390
EM	1993	858	757	1189	289
Diva	1949	794	747	1509	322
LB	1962	735	677	1484	217
Eplus	1993	829	739	1495	347
CitySim	1973	845	792	1611	367
Indalux	1958	855	797	1569	366
Honeybee	1967	877	710	1561	302
Relative Max. difference (%)	2	29	18	35	80
Absolute Max. difference (Wh/m²)	44	214	120	422	174

Workflows dissection

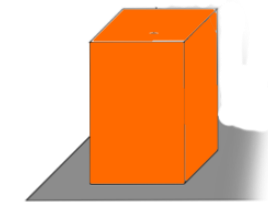
Workflow CadSol:



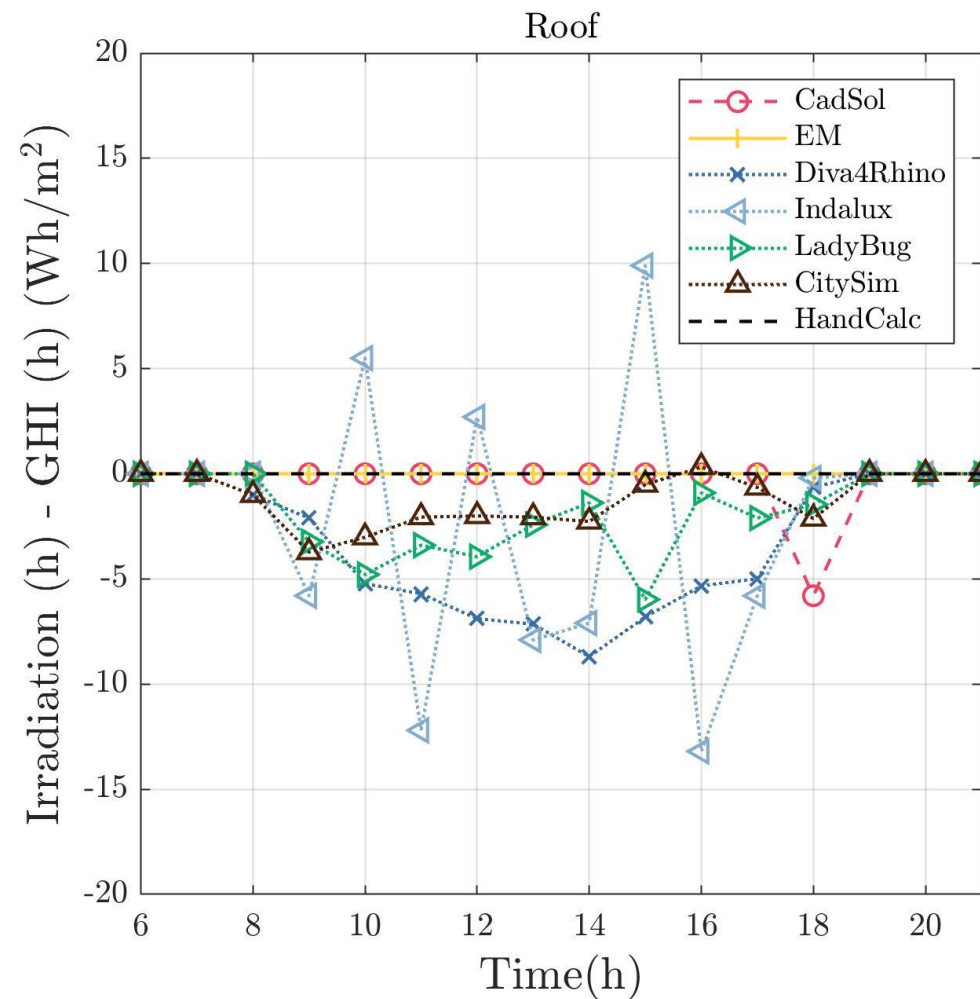
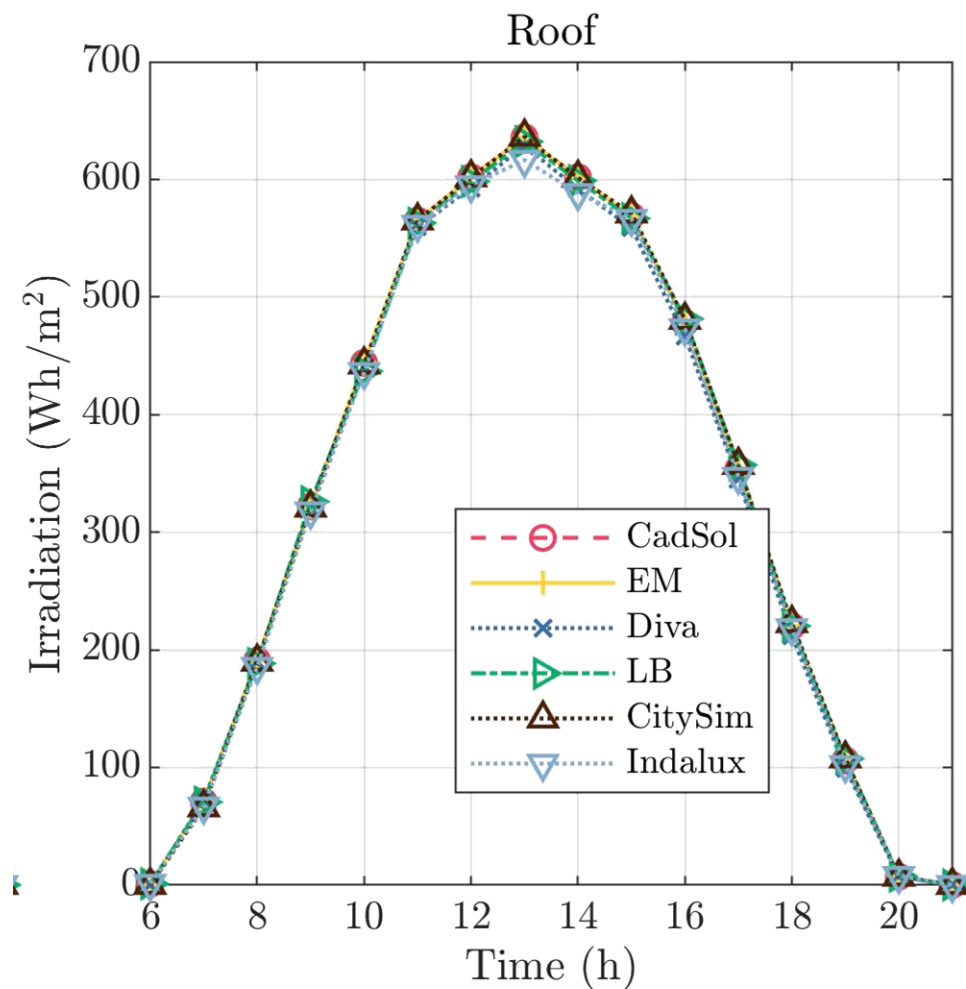
Workflow Indalux:



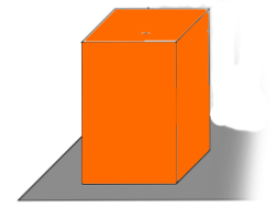
Benchmark results – Unshaded flat roof



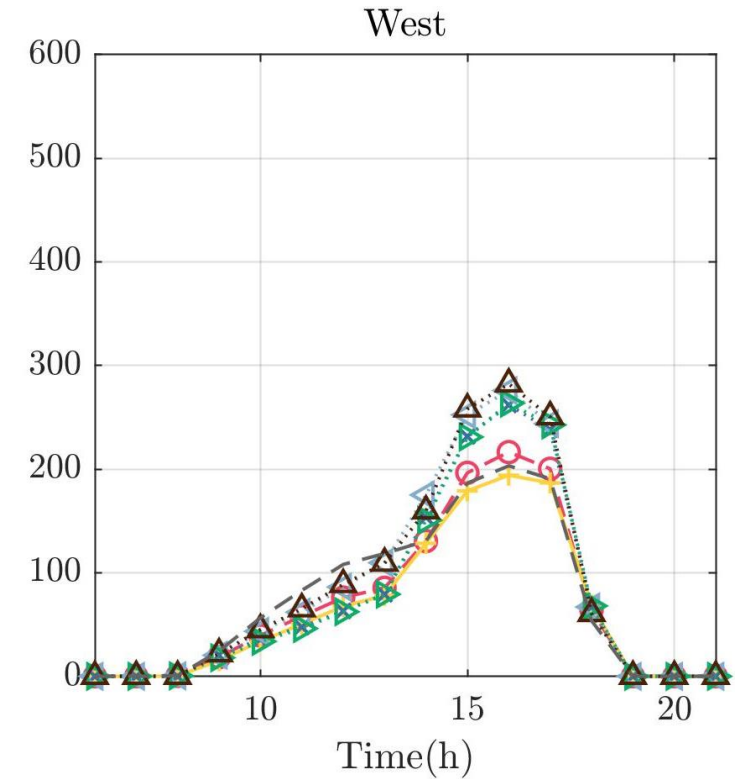
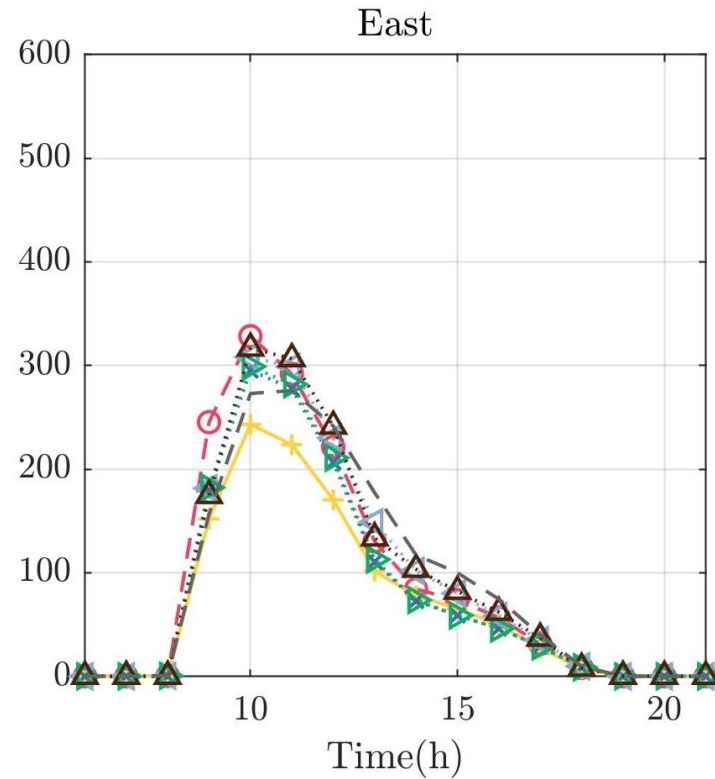
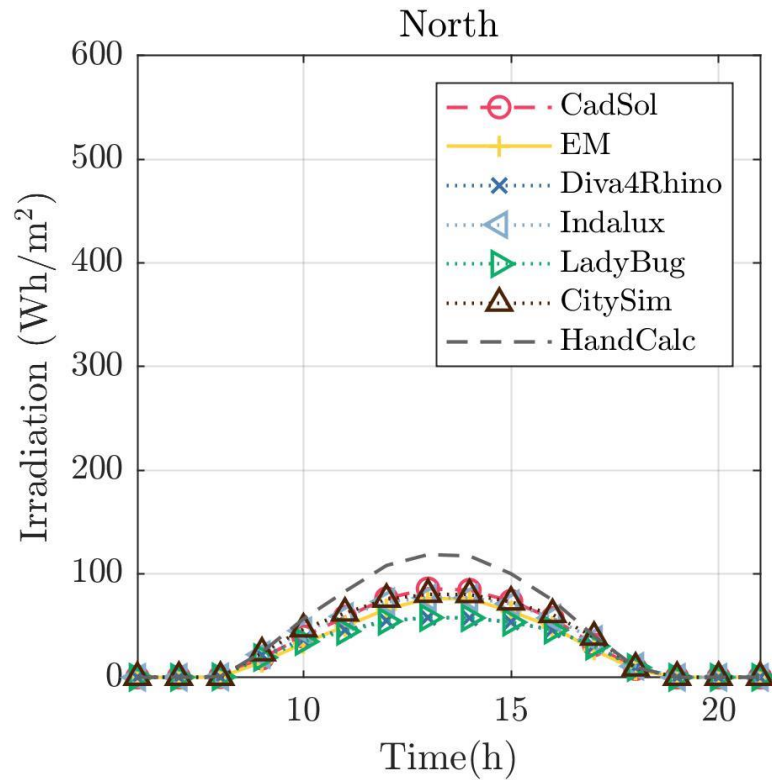
15th of february



Unshaded façades

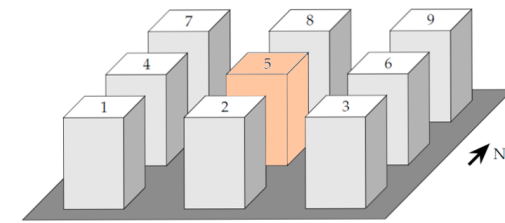


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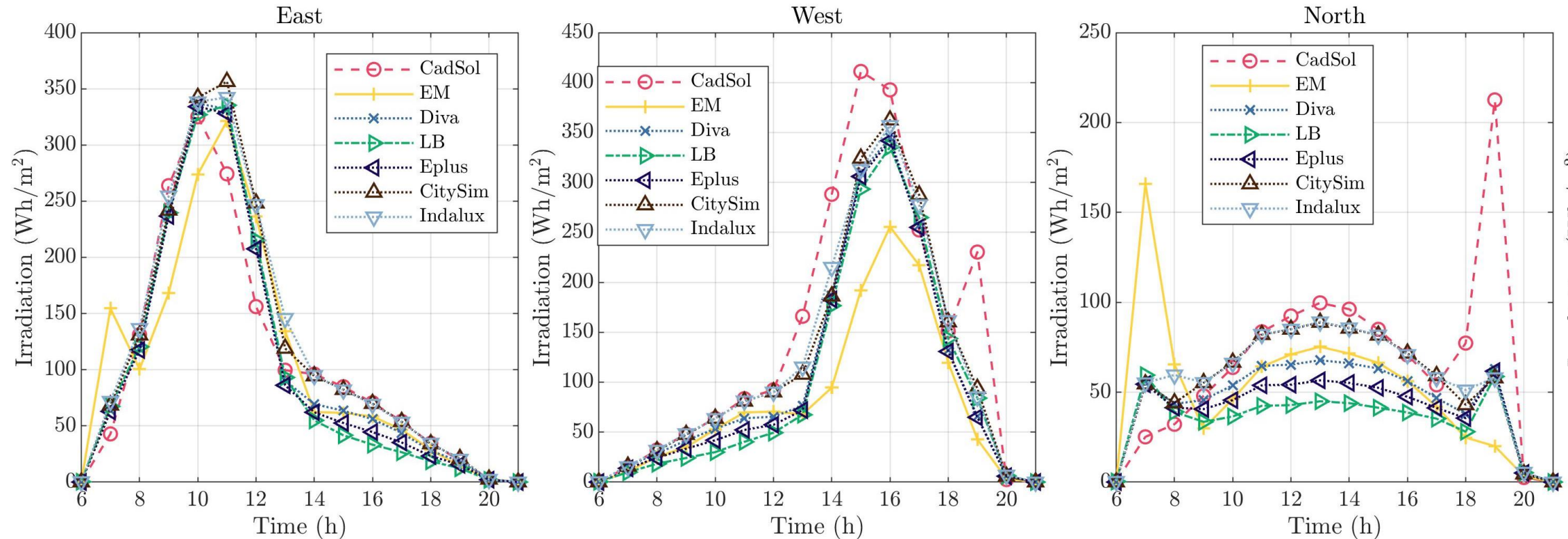


- Differences increase, but qualitative agreement

Homogeneous district



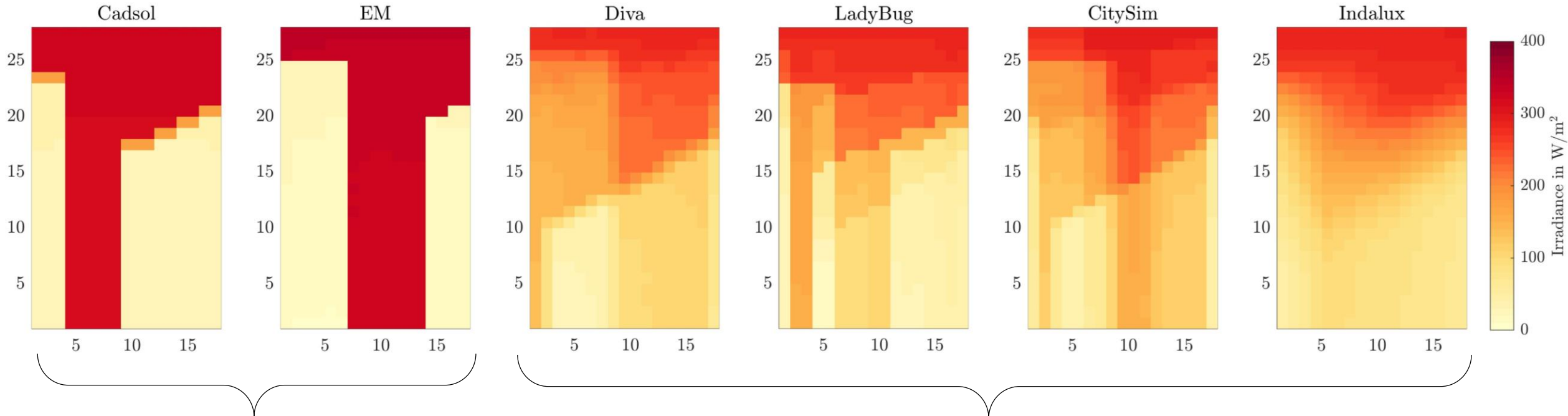
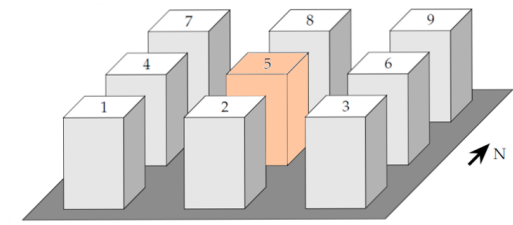
16th of August



- The surroundings induce more complex behaviors and more discrepancies
- Similar results LB, Diva and Indalux ont des variations très proches -> Même moteur de calcul
- Presence of 'peaks' (CadSol, EM) (Critical hours without time sub-sampling)

Homogeneous district – facade mapping

16th of August 10 AM in the morning



- No time sub-sampling
- Slighth shift of the solar repartition
 - Shift in the solar path

Time sub-sampling:

$$Irradiance(h) = \frac{1}{N} \sum_{k=1}^N Irradiance(h - \frac{k}{N})$$

Conclusion

- For the exact same initial conditions:
 - Good agreements for daily cumulative energy on unshaded roofs (2%).
 - Not so good agreements for vertical façades 18% (West) up to 80% (North)
 - Large differences are observed in the spatial distribution

Perspectives

- Experimental measurements on façades for confrontation
- Lesson learnt: how to improve actual tools, how to develop new methods and tools
- Comparing physical hypothesis (modelling of the diffuse component, impact of local microclimate, ...)